SR 95 Corridor Profile Study

JUNCTION I-8 TO JUNCTION I-40

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WORKING PAPER 2: BASELINE CORRIDOR PERFORMANCE

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TABLE OF CONTENTS

1 Introduction 1

1.1 Corridor Overview ... 1
1.2 Study Purpose ... 1
1.3 Study Objectives ... 1
1.4 Study Location and Corridor Segments ... 2
1.5 Working Paper 2 Objectives ... 3

2 Performance Framework Overview 5

3 Corridor Health 6

3.1 Pavement Performance Area ... 6
3.2 Bridge Performance Area ... 12
3.3 Mobility Performance Area ... 18
3.4 Safety Performance Area ... 30
3.5 Freight Performance Area ... 37

4 Corridor Performance Summary 44

5 Agency Discussions 48

Appendix A – Performance Methodology Refinements 50

A. Pavement ... 50
B. Bridge ... 50
C. Mobility ... 50
D. Safety ... 50
E. Freight ... 51

Appendix B – Performance Area Detailed Calculation Methodologies 51

Pavement Performance Area Calculation Methodologies ... 51
Bridge Performance Area Calculation Methodologies ... 55
Mobility Performance Area Calculation Methodologies ... 57
Safety Performance Area Calculation Methodologies ... 64
Freight Performance Area Calculation Methodologies ... 70

LIST OF TABLES

Table 1 - SR 95 Corridor Segments ... 3
Table 2 - PSR and PDI Thresholds ... 7
Table 3 - Pavement Performance Summary ... 8
Table 4 - Bridge Performance Summary ... 13
Table 5 - Mobility Performance Summary ... 21
Table 6 - Safety Performance Summary ... 32
Table 7 - Freight Performance Summary ... 39
Table 8 - Performance Summary ... 45

LIST OF FIGURES

Figure 1 - Location Map and Corridor Segments ... 4
Figure 2 - Corridor Profile Performance Framework ... 5
Figure 3 - Performance Area Measures ... 6
Figure 4 - Pavement Performance Area ... 6
Figure 5 - Pavement Index ... 9
Figure 6 - Pavement Serviceability ... 10
Figure 7 - Pavement Failure ... 11
Figure 8 - Bridge Performance Area ... 12
Figure 9 - Bridge Index ... 14
Figure 10 - Bridge Sufficiency ... 15
Figure 11 - Functionally Obsolete Bridges ... 16
Figure 12 - Bridge Rating ... 17
Figure 13 - Mobility Performance Area ... 18
Figure 14 - Mobility Index ... 22
Figure 15 - Future Mobility ... 23
Figure 16 - Existing Peak Hour V/C ... 24
Figure 17 - Closures in Occurrences per Year per Mile Compared to State Average ... 25
Figure 18 - All Vehicles Travel Time Index ... 26
Figure 19 - All Vehicles Planning Time Index ... 27
Figure 20 - Multimodal Opportunities ... 28
Figure 21 - Percent Bicycle Accommodation ... 29
Figure 22 - Safety Performance Area Measures ... 30
Figure 23 - Safety Index ... 33
Figure 24 - Directional Safety Index ... 34
Figure 25 - Frequency of SHSP Top 5 Emphasis Areas ... 35
Figure 26 - Crash Hot Spots ... 36
Figure 27 - Freight Performance Area Measures ... 37
Figure 28 - Freight Index ... 40
Figure 29 - Truck Travel Time Index ... 41
Figure 30 - Truck Planning Time Index ... 42
Figure 31 - Closures in Hours per Mile per Year ... 43
Figure 32 - Performance Index Summary ... 44
Figure 33 - Summary of Overall Corridor Performance for Primary Measures ... 46
Figure 34 - Summary of Overall Corridor Performance for Primary and Secondary Measure ... 47

LIST OF APPENDICES

Appendix A – Performance Methodology Refinements
Appendix B – Performance Area Detailed Calculation Methodologies

ACRONYMS AND ABBREVIATIONS

ABBREVIATION	NAME
AADT	Annual Average Daily Traffic
ABISS	Arizona Bridge Information and Storage System
ADOT	Arizona Department of Transportation
AZTDM	Arizona Travel Demand Model
bqAZ	Building a Quality Arizona
BI	Bridge Index
CA	California
CR	Cracking Rating
CSS	Combined Safety Score
DCR	Design Concept Report
DHV	Design Hour Volume
EB	Eastbound
FI	Freight Index
HCRS	Highway Condition Reporting System
HERS	Highway Economic Requirements Systems
HPMS	Highway Performance Monitoring System
I	Interstate
IRI	International Roughness Index
LHMPO	Lake Havasu Metropolitan Planning Organization
LOS	Level of Service
MAP-21	Moving Ahead for Progress in the 21st Century
MI	Mobility Index
MP	Milepost
MPD	Multimodal Planning Division
NACOG	Northern Arizona Council of Governments
P2P Link	Planning to Programming Link

ABBREVIATION	NAME
PI	Pavement Index
PDI	Pavement Distress Index
PSR	Pavement Serviceability Rating
SI	Safety Index
SOV	Single Occupancy Vehicle
SR	State Route
SHSP	Strategic Highway Safety Plan
TPI	Planning Time Index
TTI	Travel Time Index
TPTI	Truck Planning Time Index
TTTI	Truck Travel Time Index
US	United States Route
V/C	Volume-to-Capacity
WACOG	Western Arizona Council of Governments
YMPO	Yuma Metropolitan Planning Organization
WB	Westbound

1 Introduction

The Arizona Department of Transportation (ADOT) is conducting eleven Corridor Profile Studies. The Corridor Profile Study process is a comprehensive process to:

- Inventory past project implementation proposals for each of the eleven strategic corridors.
- Provide an overall assessment of the existing health of the corridor based on performance measures.
- Propose various solution sets to help improve overall corridor performance.
- Recommend the most strategic improvements for the corridor.

The eleven corridors are being evaluated within three separate groupings.

The first three studies (Round 1) began in spring 2014, and encompass:

- I-17: Jct. SR 101L to Jct. I-40
- I-19: Mexico Border to Jct. I-10
- I-40: California Stateline to Jct. I-17

The second round (Round 2) of studies, initiated in spring 2015, include:

- I-8: California Stateline to Jct. I-10
- I-40: Jct. I-17 to New Mexico Stateline
- SR 95: Jct. I-8 to Jct. I-40

The third round (Round 3) of studies, to be initiated in fall 2015 include:

- I-10: California Stateline to Jct. SR 85 and SR 85: Jct. I-10 to Jct. I-8
- I-10: Jct. SR 202L to New Mexico State Line
- SR 87/SR 260/SR 377: Jct. SR 202L to Jct. I-40
- US 60/US 70: Jct. SR 79 to Jct. US 191 and US 191: Jct. US 70 to Jct. SR 80
- US 93/US 60: Nevada State Line to Jct. SR 303L

The studies under this program will provide a strategic vision for assessing the overall health of the state's strategic highways, assisting the agency with transitioning to a performance-based project programming system through targeted investments. The Corridor Profile Studies will identify candidate projects for consideration in the Multimodal Planning Division's (MPD) Planning to Programming (P2P) project prioritization process providing information to guide corridor-specific project selection and programming decisions.

1.1 Corridor Overview

The US 95 portion of the SR 95 corridor runs between I-8 and I-10 and connects the cities of Yuma and Quartzsite while including areas such as the U.S. Army Yuma Proving Ground (YPG) and General Motors Desert Proving Ground – Yuma. The SR 95 portion of the SR 95 corridor runs between I-10 and I-40 and connects the cities of Quartzsite, Parker, and Lake Havasu City. This corridor also serves and passes through the Colorado River Indian Tribe reservation.

1.2 Study Purpose

The purpose of a corridor profile study is to provide insight and results to connect the strategic visions developed in Building a Quality Arizona (bqAZ) to performance-based planning and programming processes known as Planning to Programming Linkages (P2P Link) that satisfy both funding constraints and progress towards realizing the bqAZ vision. In support of this study purpose, the SR 95 Corridor Profile Study, Junction I-8 to Junction I-40, will define and address current and future needs in the SR 95 corridor using a study process that can be applied in other corridor profile studies to establish priorities for improving Arizona's strategic corridors.

This study, as well as other corridor profile studies, will be guided by processes developed in P2P Link. P2P Link is a performance-based approach to planning, programming, and financial decisions that ensures that available funds are used in the most productive way to meet overall transportation system performance objectives. The P2P Link connects the investment strategies of the State's Long-Range Transportation Plan to ADOT's Five-Year Construction Program. This connection ensures that the policy guidance in the long-range transportation plan is adhered to in improving the State transportation system.

1.3 Study Objectives

Objectives of the SR 95 Corridor Profile Study are:

Collaborate with ADOT and others to maximize procedural consistency among all corridor profile studies.

Assess the existing performance of the corridor. Existing corridor performance will be assessed using the performance measures developed in P2P Link to ensure consistency. Input from past studies, completed projects, and the current construction program will be reviewed to determine the track-record of corridor improvements and investment strategies over recent years.

Identify performance-based emphasis areas for the corridor. The corridor will be defined in terms of future performance objectives for key emphasis areas. These emphasis areas will guide corridor preservation, modernization, and expansion.

Determine the health of the corridor and identify performance-based needs that must be addressed to achieve the performance objectives for the corridor emphasis areas. Existing performance will be compared with identified performance objectives to define corridor needs.

Develop and evaluate solution sets and corresponding investment strategies that will lead to achieving the performance objectives for the corridor emphasis areas.

Scope and prioritize solution sets and projects using criteria consistent with P2P Link and a risk assessment approach. Project scoping is a critical step to transition from solution sets to project candidates. Project scoping will include appropriate emphasis on development issues and life-cycle costing to ensure that recommendations are ready to be considered in a risk assessment framework before being considered as candidates for P2P selection and priority processes.

Document study procedures, measures, criteria, and relationships with the P2P Link to serve as guidance for future profile studies. A well-documented process will be a key requirement for creating consistency between the corridor profile studies and P2P Link selection and priority procedures.

1.4 Study Location and Corridor Segments

The location of the SR 95 Corridor Profile Study is illustrated in **Figure 1**. The SR 95 corridor serves as a route for agricultural, military, recreational, tourist, and regional traffic. The functional classification of SR 95 between I-40 and I-10 and of US 95 between I-10 and I-8 is Rural Principal Arterial. SR 95 and US 95 are both part of the National Highway System. Because the SR 95 corridor is the only continuous north-south state highway corridor that connects the three Arizona east-west interstate routes of I-8, I-10, and I-40, it is a strategic transportation link across western Arizona for freight and inter-city travel. The SR 95 corridor is located in two ADOT Districts (Yuma and Kingman); three planning areas (Yuma Metropolitan Planning Organization [MPO], Lake Havasu MPO, and Western Arizona Council of Governments [WACOG]); and three counties (Yuma, La Paz, and Mohave).

The SR 95 study corridor has been divided into 13 segments to allow for an appropriate level of detailed needs analysis, performance evaluation, and comparison between different segments of the corridor. **Figure 1** shows the thirteen corridor segments within the corridor study limits that are further described in **Table 1**.

Table 1 - SR 95 Corridor Segments

Segment Number	Begin Milepost	End Milepost	Length (miles)	Description
95-A	24	29	5	Non-ADOT Facility; City of Yuma 16th Street, traffic interchange (TI) with Interstate 8
95-1	29	34	5	Interrupted flow facility with four-lane cross-section, relatively flat terrain, transitioning urban/rural area, junction with Araby Road and Fortuna Road, private land ownership
95-2	34	43	9	Uninterrupted flow facility with a two-lane cross-section, rolling terrain, rural, Bureau of Land Management (BLM), Bureau of Reclamation
95-3	43	60	17	Uninterrupted flow facility with 2-lane cross-section, flat terrain, rural, Military land ownership (Laguna Army Airfield, Yuma Proving Ground), General Motors Desert Proving Ground Yuma, junction with Imperial Dam Road
95-4	60	80	20	Uninterrupted flow facility with 2-lane cross-section, relatively flat terrain, rural, Bureau of Land Management, Kofa National Wildlife Refuge, Military land ownership, Border Patrol check point.
95-5	80	104	24	Uninterrupted flow facility with 2-lane cross-section, flat terrain, Bureau of Land Management, Kofa National Wildlife Refuge
95-6	104	111	7	Interrupted flow with 5-lane cross-section, urban area type within Quartzsite, Private land ownership, Bureau of Land Management, State Trust Land, junction with Interstate 10, Transition from US 95 to SR 95
95-7	111	131	20	Uninterrupted flow facility with 2-lane cross-section, flat terrain, rural, Bureau of Land Management, State Trust Land
95-8	131	142	11	Uninterrupted flow facility with 2-lane cross-section, flat, rural, Bureau of Land Management, State Trust Land, Tribal Land, junction with SR 72
95-9	142	149	7	Interrupted flow with 5-lane cross-section, relatively flat with some grade variation, urban area type within Parker to Cienega Springs. Private land ownership, Tribal Land
95-10	149	162	13	Uninterrupted flow facility with cross-sections varying from 2 lanes to 4 lanes, rolling terrain, rural with some communities within the vicinity of the corridor, State Trust Land
95-11	162	176	14	Uninterrupted flow facility with 2-lane cross-section, rolling terrain, rural, Bureau of Land Management, U.S. Fish and Wildlife Service, State Trust Land
95-12	176	190	14	Interrupted flow facility with 5-lane cross-section, flat terrain, urban area type within Lake Havasu City and Desert Hills, Private land ownership, State Trust Land
95-13	190	202	12	Uninterrupted flow facility with cross-sections varying from 2 lanes to 4 lanes, rolling hills type terrain, rural, Bureau of Land Management, junction with I-40

1.5 Working Paper 2 Objectives

The purpose of Working Paper 2 is to quantify the performance-based health of the SR 95 corridor within the study limits. The health of the corridor is characterized using performance measures developed and evaluated for five performance areas: pavement, bridge, mobility, safety, and freight. The product of Working Paper 2 is baseline performance assessments for the corridor and its component segments. Baseline performance will be compared to corridor performance objectives (developed in Working Paper 3), which will be used to identify corridor segments and locations that warrant further diagnostic analyses to determine performance-based needs that will lead to preservation, modernization, and expansion solutions for meeting corridor performance objectives.

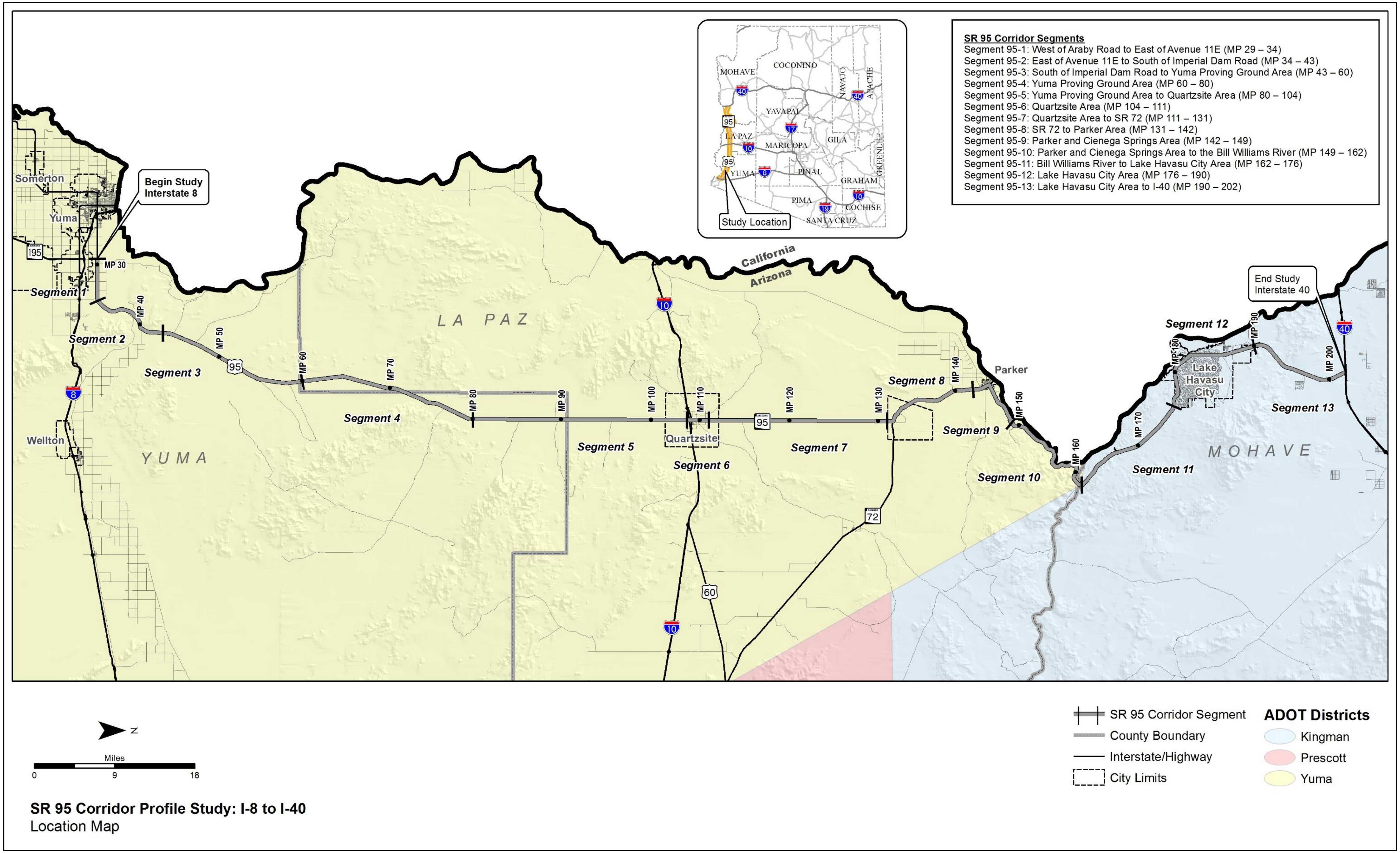


Figure 1 - Location Map and Corridor Segments

2 Performance Framework Overview

An objective of the ADOT Corridor Profile Studies is to use a performance-based process to define baseline corridor performance, diagnose corridor needs and deficiencies, develop corridor solutions, and prioritize strategic corridor investments. In support of this study objective, a framework for the performance-based process was developed through a collaborative process involving ADOT and the consultant teams for the I-8, I-40, and SR 95 Corridor Profile Studies. In the performance framework illustrated in **Figure 2**, baseline performance is evaluated using primary and secondary performance measures to define the health of the corridor and identify locations that warrant further diagnostic investigation to define needs and deficiencies.

Needs and deficiencies are defined as the difference in baseline corridor performance compared to established performance goals and objectives. Corridor improvements and strategies are characterized in the ADOT transportation plan as investment options for preserving, modernizing, and expanding corridor infrastructure to improve corridor performance. Improvement priorities are evaluated using ADOT's P2P Link processes.

Five performance areas were defined to guide the performance-based corridor analyses. The five performance areas include:

- Pavement performance
- Bridge performance
- Mobility performance
- Safety performance
- Freight Performance

These performance areas reflect the seven *Moving Ahead for Progress in the 21st Century* (MAP-21) national performance goals, which are listed below.

- **Safety:** To achieve a significant reduction in traffic fatalities and serious injuries on all public roads
- **Infrastructure condition:** To maintain the highway infrastructure asset system in a state of good repair
- **Congestion reduction:** To achieve a significant reduction in congestion on the National Highway System
- **System reliability:** To improve the efficiency of the surface transportation system
- **Freight movement and economic vitality:** To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development
- **Environmental sustainability:** To enhance the performance of the transportation system while protecting and enhancing the natural environment
- **Reduced project delivery delays:** To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion

The above national performance goals also were considered in the development of ADOT's P2P Link for linking transportation planning to capital improvement programming and project delivery. Because P2P Link requires the preparation of annual transportation system performance reports using the five performance areas adopted for the ADOT Corridor Profile Studies, consistency is achieved in the performance measures used for various ADOT analysis processes.

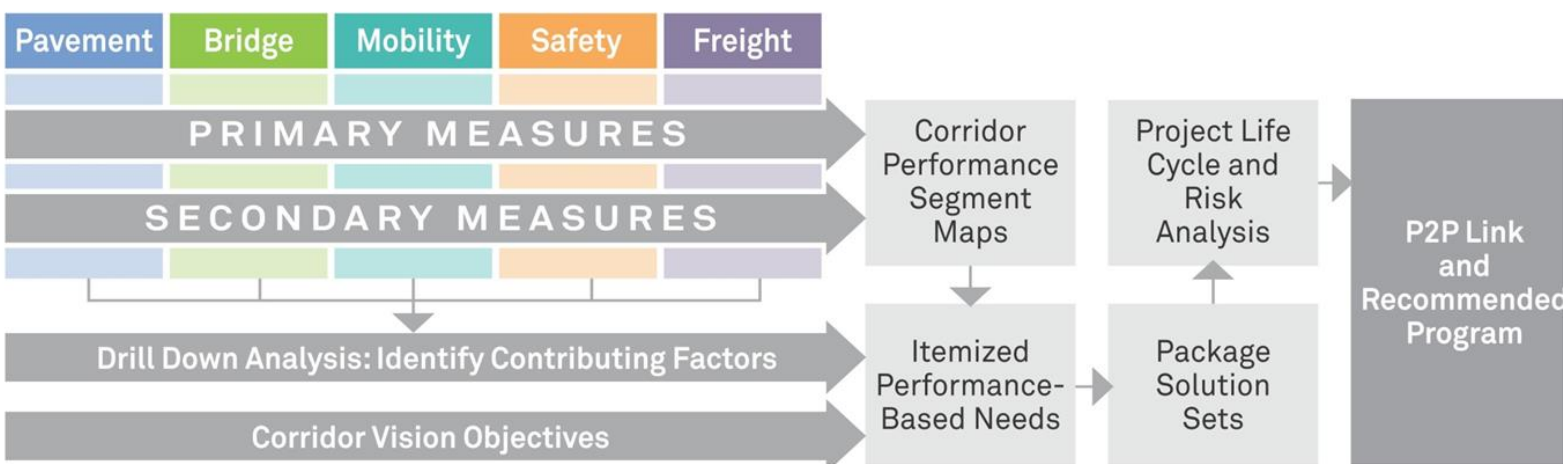


Figure 2 - Corridor Profile Performance Framework

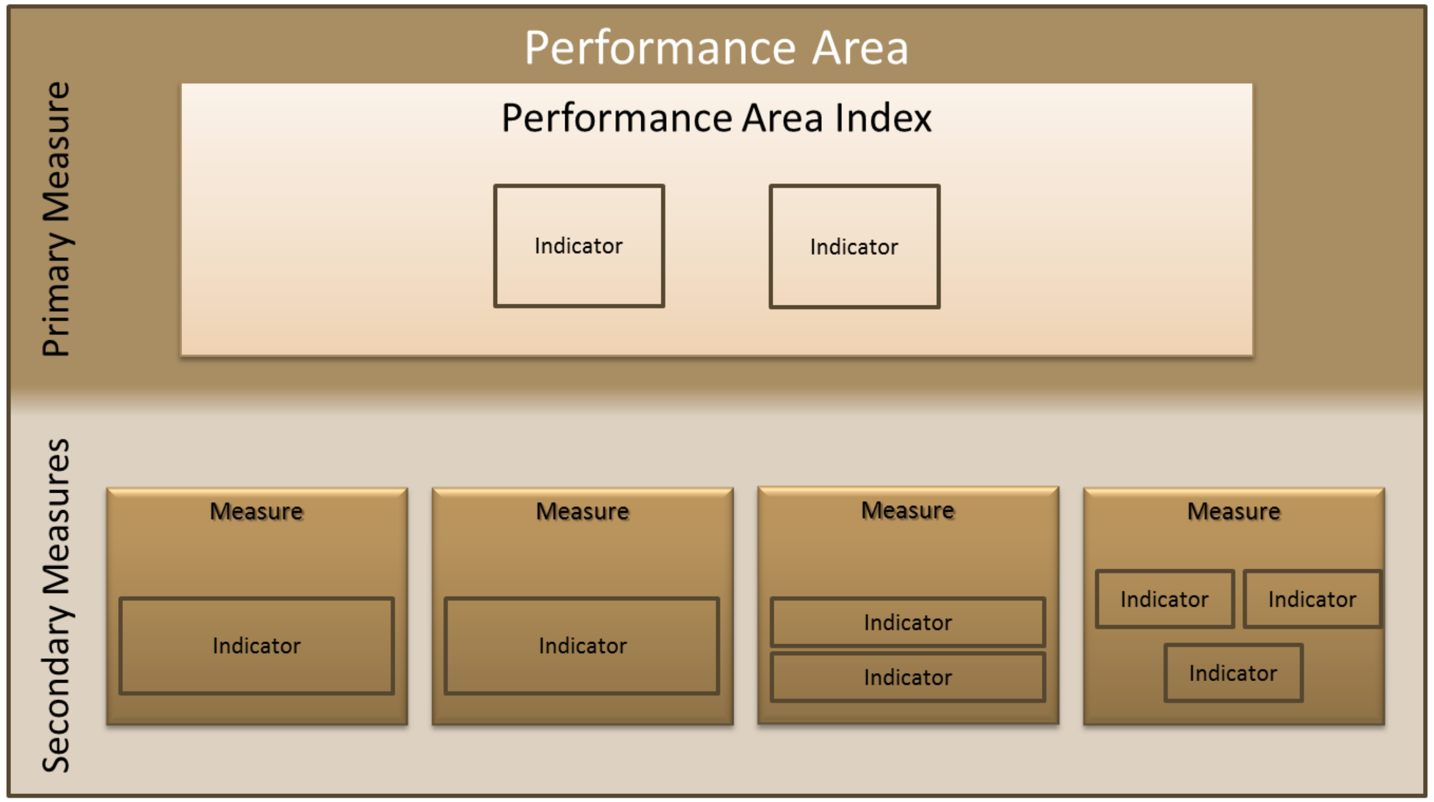


Figure 3 - Performance Area Measures

The generic framework for each performance area is illustrated in **Figure 3**. The guidelines for performance measure development are listed below:

- Indicators (or performance measures) for each performance area should be developed for relatively homogeneous corridor segments.
- Performance measures for each performance area should be tiered, consisting of primary measure(s) and secondary measure(s).
- Primary and secondary measures will assist in identifying those corridor segments that warrant in-depth diagnostic analyses to identify performance-based needs and a range of corrective actions known as solution sets.
- One or more primary performance measures should be used to develop a Performance Area Index to communicate the overall health of a corridor and its segments for each performance area. The Performance Index should be a single numerical index that is quantifiable, repeatable, scalable, and capable of being mapped. Primary performance measures should be transformed into a performance index using mathematical or statistical methods to combine one or more data fields from an available ADOT database.
- The principal use of the one or more secondary performance measures should be to provide additional details to define corridor locations that warrant further diagnostic analysis. Secondary performance measures may include the individual measures used to calculate the Performance Index and/or "hot spot" features.

Lessons learned from subsequent tasks in Round 1, and application of the performance framework to a non-interstate facility (SR 95) resulted in refinements to the performance methodology that will be applied to Round 2. These refinements are described in **Appendix B**.

3 Corridor Health

3.1 Pavement Performance Area

The Pavement Performance Area consists of a single primary measure (Pavement Index) and three secondary measures, as shown in **Figure 4**, to assess the condition of the existing pavement along the corridor. The performance system was developed in collaboration with ADOT Materials Group.

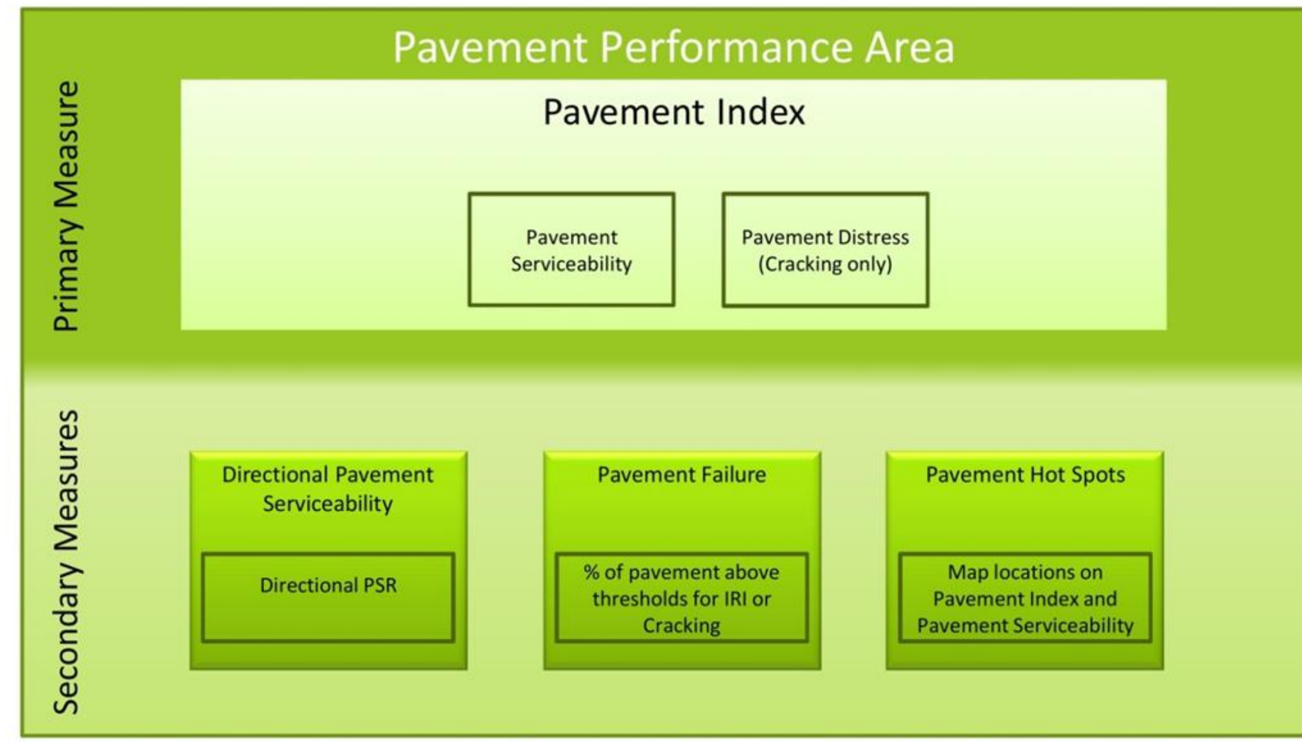


Figure 4 - Pavement Performance Area

For the Pavement Performance Area, only mainline pavement was included in the calculation. Pavement condition data for ramps, frontage roads, crossroads, etc. was not included. Detailed information related to the calculations for the Pavement Performance area is included in **Appendix B** of this Working Paper.

3.1.1 Primary Measure: Pavement Index

The Pavement Index is calculated based on the use of two pavement condition ratings from the ADOT Pavement Database. The two ratings are the International Roughness Index (IRI) and the Cracking Rating (CR). The calculation of the Pavement Index uses a combination these two ratings. These two ratings were used for the primary measure because they represent the data used by ADOT Materials Group to assess the need for pavement rehabilitation.

The IRI is a measurement of the pavement roughness based on field-measured longitudinal roadway profiles. To facilitate the calculation of the index, the IRI rating was converted to a Pavement Serviceability Rating (PSR) using the following equation:

$$PSR = 5 * e^{-0.0038*IRI}$$

The CR is a measurement of the amount of surface cracking based on a field-measured area of 1,000 square feet that serves as a sample for each mile. To facilitate the calculation of the index, the CR was converted to a Pavement Distress Index (PDI) using the following equation:

$$PDI = 5 - (0.345 * CR^{0.66})$$

Both the PSR and PDI use a 0 to 5 scale with 0 representing the lowest performance and 5 representing the highest performance. The performance thresholds shown in the **Table 2** below were used for the PSR and PDI.

Table 2 - PSR and PDI Thresholds

Condition	Interstates		Non-Interstates	
	IRI (PSR)	Cracking (PDI)	IRI (PSR)	Cracking (PDI)
Good	<75 (>3.75)	<7 (>3.75)	<94 (>3.50)	<9 (>3.50)
Fair	75 - 117 (3.20 - 3.75)	7 - 12 (3.22 - 3.75)	94 - 142 (2.90 - 3.50)	9 - 15 (2.90 - 3.50)
Poor	>117 (<3.20)	>12 (<3.22)	>142 (<2.90)	>15 (<2.90)

The PSR and PDI are calculated for each 1-mile section of roadway. If the PSR or PDI falls into a poor rating (see table above) for a 1-mile section, then the score for that 1-mile section is entirely (100%) based on the lower score (either PSR or PDI). If neither PSR or PDI fall into a poor rating for a 1-mile section, then the score for that 1-mile section is based on a combination of the lower rating (70% weight) and the higher rating (30% weight). The end result is a score between 0 and 5 for each direction of travel of each mile of roadway based on a combination of both the PSR and the PDI.

The Pavement Index for each segment is a weighted average of the directional ratings based on the number of travel lanes. Therefore, the condition of a section with more travel lanes will have a greater influence on the resulting segment Pavement Index than a section with fewer travel lanes. The performance thresholds for the Pavement Index are as follows:

Interstate Facilities

- Good: > 3.75
- Fair: 3.20 - 3.75
- Poor: < 3.20

Non-Interstate Facilities

- Good: > 3.50
- Fair: 2.90 - 3.50
- Poor: < 2.90

3.1.2 Secondary Pavement Measures

The Pavement Performance Area has three secondary performance measures discussed herein:

- Directional Pavement Serviceability
- Pavement Failure
- Pavement Hot Spots

Directional Pavement Serviceability

Similar to the Pavement Index, the Directional Pavement Serviceability is calculated as a weighted average (based on number of lanes) for each segment. However, this rating will only utilize the PSR and will be calculated separately for each direction of travel. The PSR uses a 0 to 5 scale with 0 representing the lowest performance and 5 representing the highest performance. The purpose of this secondary measure is to assess the condition of the pavement in each direction of travel. The thresholds for the Directional Pavement Serviceability are as follows:

Interstate Facilities

- Good: > 3.75
- Fair: 3.20 - 3.75
- Poor: < 3.20

Non-Interstate Facilities

- Good: > 3.50
- Fair: 2.90 - 3.50
- Poor: < 2.90

Pavement Failure

This secondary measure calculates the percentage of pavement area for each segment that is rated above the failure thresholds for IRI or Cracking, as established by ADOT Materials Group (IRI > 105 or Cracking > 15 for Interstates, and IRI > 142 or Cracking > 15 for Non-Interstates). The pavement area within each segment that has been identified in poor condition will be totaled and divided by the total pavement area for the segment to calculate the percentage of pavement area in poor condition for each segment. Based on the data from the I-17, I-19, I-40, I-8, and SR 95 corridors, the thresholds for the Pavement Failure are as follows:

- Above average performance (Good): < 5%
- Average performance (Fair): 5% - 20%
- Below average performance (Poor): > 20%

Pavement Hot Spots

A pavement "hot spot" exists where a given 1-mile section of roadway rates as being in "poor" condition per Table 2. This measure is mapped for graphical display purposes but is not included in the Pavement Performance Area rating calculations.

3.1.3 SR 95 Pavement Performance

The Pavement Index and Secondary Performance Measures were calculated for the SR 95 corridor using the Pavement Performance Area methodology (**Appendix B**). The input data represents the most recently collected pavement conditions, provided by ADOT, from 2014, except that pavement data for segment 95-13 is from 2013 due to construction on that segment during 2014. The resulting performance scores are shown in **Table 3**. The results for the Pavement Index and the Secondary Measures are mapped in **Figure 5 – Figure 7**.

Based on the results of the analysis, the following pavement conditions were observed on SR 95:

- The weighted average of the Pavement Index indicates "good" overall pavement conditions for the SR 95 corridor.
- Segment 13 has "poor" Pavement Index and % Area Failure ratings of 2.77 and 24.7%, respectively.
- Segment 6 and Segment 8 have "fair" Pavement Index ratings.
- Segment 3 and Segment 6 both have "poor" % Area Failure ratings of more than 30%.
- As shown in **Figure 5** and **Figure 6,** pavement hot spots exist in Segments 3, 6, 7, 8, 9, 12, and 13.

Table 3 - Pavement Performance Summary

Segment	Segment Length (miles)	Pavement Performance Area			
		Pavement Index	Directional PSR		% Area Failure
			NB	SB	
95-1	5	3.54	3.64		0.0%
95-2	9	3.82	3.78		0.0%
95-3	17	3.61	3.51		35.3%
95-4	20	4.41	4.28		0.0%
95-5	24	4.14	4.12		0.0%
95-6	2.5	3.27	3.23		33.3%
95-7	20	3.68	3.76		5.0%
95-8	11	3.39	3.27		9.1%
95-9	6	3.59	3.84		14.3%
95-10	14	3.62	3.59		0.0%
95-11	14	4.13	4.13		0.0%
95-12	14	3.77	3.51	4.15	14.3%
95-13	12	2.77	3.77		24.7%
Weighted Average		3.65	3.80	3.86	8.7%

Good	> 3.50	> 3.50	< 5%
Fair	2.90 - 3.50	2.90 - 3.50	5% - 20%
Poor	< 2.90	< 2.90	> 20%

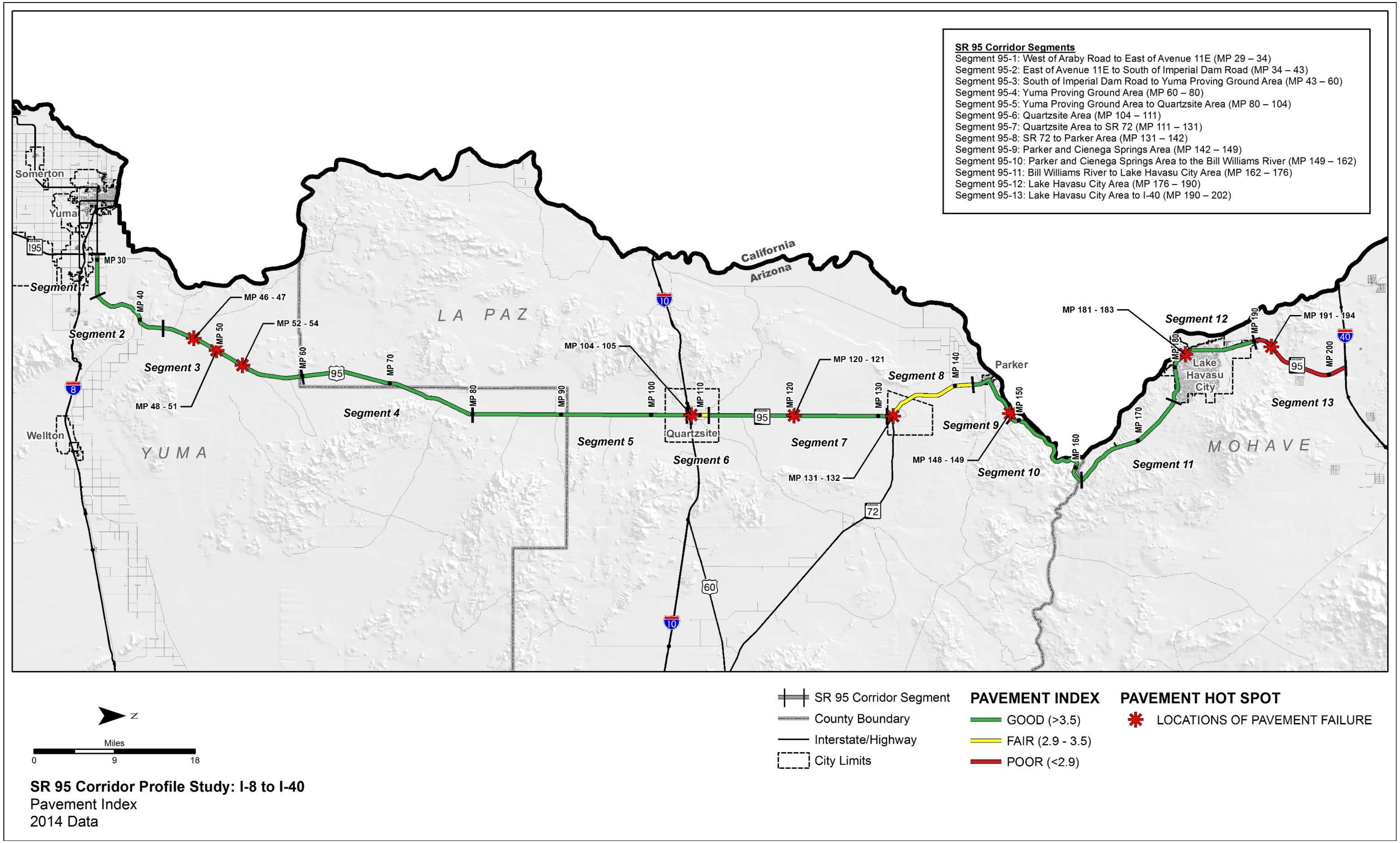


Figure 5 - Pavement Index

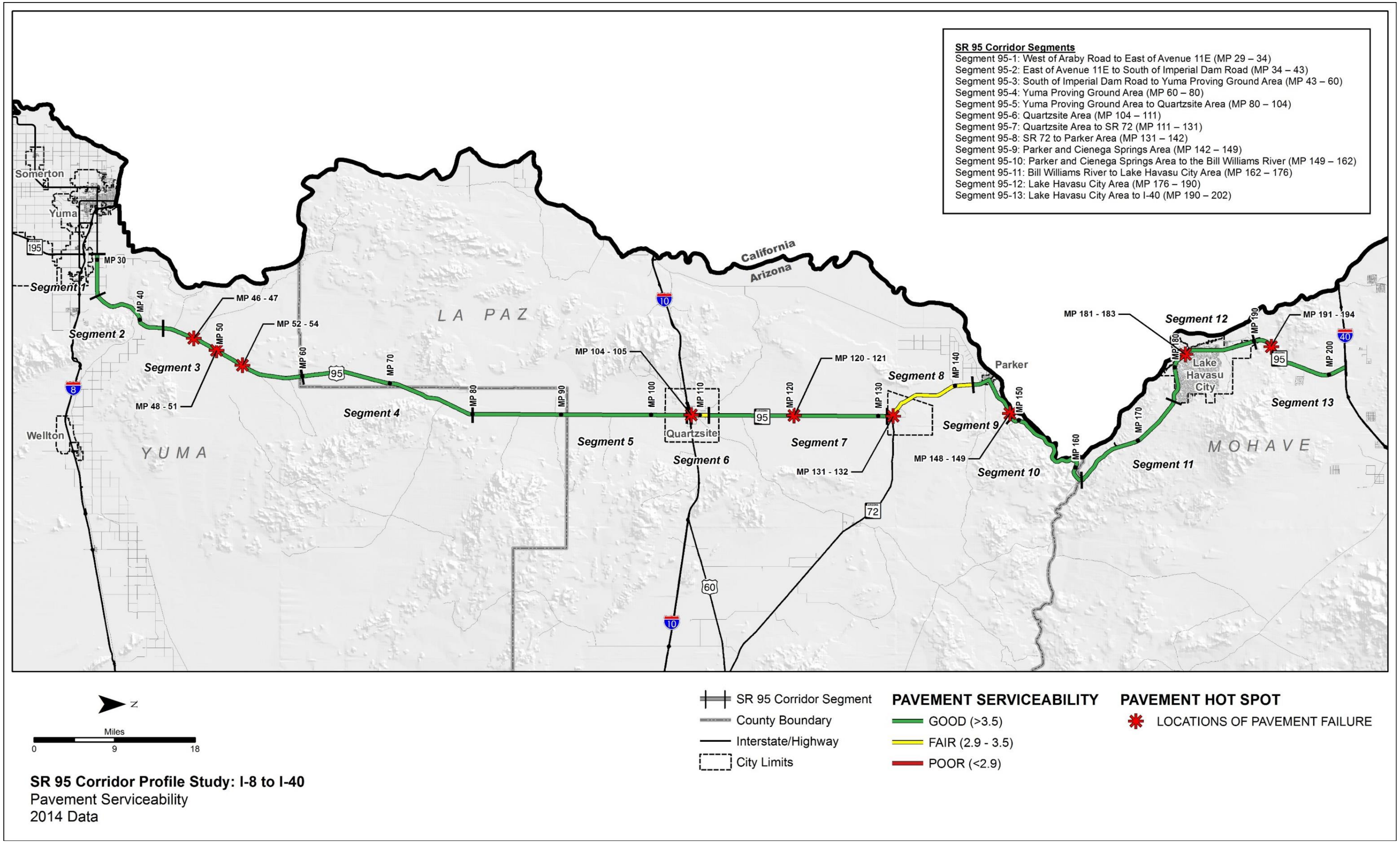
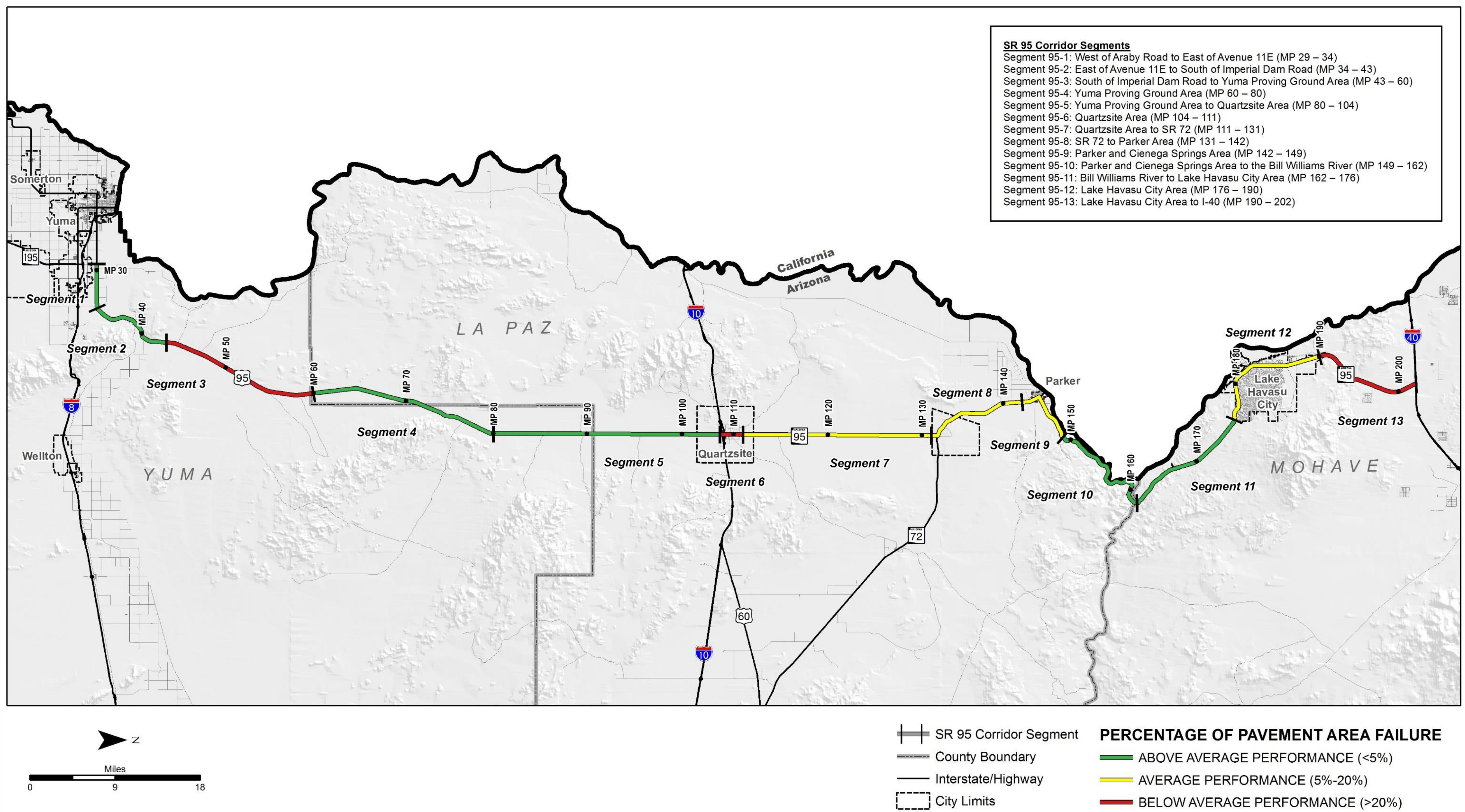


Figure 6 - Pavement Serviceability



SR 95 Corridor Profile Study: I-8 to I-40
Percentage of Pavement Area Failure
2014 Data

Figure 7 - Pavement Failure

3.2 Bridge Performance Area

The Bridge Performance Area consists of a primary measure (Bridge Index) and four secondary measures, as shown in **Figure 8**, to assess the condition of the existing bridges along the corridor. The performance system was developed in collaboration with ADOT Bridge Group.

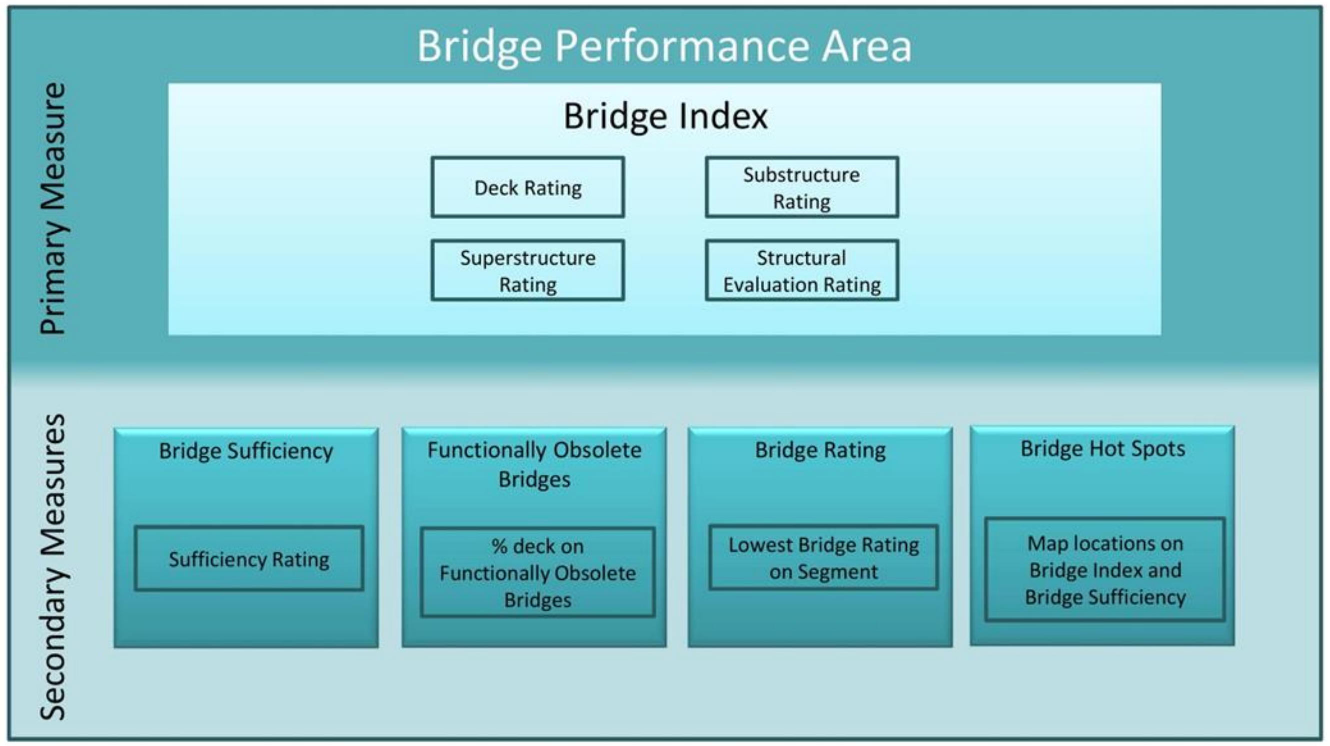


Figure 8 - Bridge Performance Area

For the Bridge Performance Area, only bridges that carry mainline traffic or bridges that cross the mainline were included in the calculation. Bridges that do not carry mainline traffic or do not cross the mainline were not included. Detailed information related to the calculations for the Bridge Performance area is included in **Appendix B** of this Working Paper.

3.2.1 Primary Measure: Bridge Index

The Bridge Index is calculated based on the use of four bridge condition ratings from the ADOT Bridge Database, also known as the Arizona Bridge Information and Storage System (ABISS). The four ratings are the Deck Rating, Substructure Rating, Superstructure Rating, and Structural Evaluation Rating. These ratings are based on inspection reports and are used to establish the structural adequacy of the bridge. The condition of each individual bridge is established by using the lowest of these four ratings. The use of these ratings, and the use of the lowest rating, is consistent with the approach used by ADOT Bridge Group to assess the need for bridge rehabilitation.

Each of the four condition ratings uses a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. As defined by ADOT Bridge Group, a rating of 7 or above represents “good” performance, a rating of 5 or 6 represents “fair” performance, and a rating of 4 or below represents “poor” performance.

To report the Bridge Index for each corridor segment, the Bridge Index for each segment is a weighted average condition rating based on the deck area for each bridge. Therefore, the condition of a larger bridge will have a greater influence on the resulting segment Bridge Index than a smaller bridge. The resulting Bridge Index is based on a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. The performance thresholds for the Bridge Index are as follows:

- Good: > 6.5
- Fair: 5.0 - 6.5
- Poor: < 5.0

3.2.2 Secondary Measures

The Bridge Performance Area has four secondary measures discussed herein:

- Bridge Sufficiency Rating
- Functionally Obsolete Bridges
- Bridge Rating
- Bridge Hot Spots

Bridge Sufficiency Rating

The Sufficiency Rating for each bridge is available from the ADOT ABISS system. The Sufficiency Rating is calculated by using numerous factors to obtain a numeric value which is indicative of bridge sufficiency to remain in service. The result of this method is a percentage in which 100% would represent an entirely sufficient bridge and 0% would represent an entirely insufficient or deficient bridge. The factors that contribute to the Sufficiency Rating include structural adequacy and safety, serviceability and functional obsolescence, and essentiality for public use. The Bridge Sufficiency rating was used as a secondary measure (instead of a primary measure) because it includes a broad range of information to assess the condition of the bridge including the amount of traffic and the length of detour, but does not directly relate to the structural adequacy of the bridge.

Similar to the Bridge Index, the Bridge Sufficiency Rating is calculated as a weighted average (based on deck area) for each segment. The Sufficiency Rating is a scale of 0 to 100 with 0 representing the lowest performance and 100 representing the highest performance. The performance thresholds for the Bridge Sufficiency Rating are as follows:

- Good: > 80
- Fair: 50 - 80
- Poor: < 50

Functionally Obsolete Bridges

Functionally Obsolete means that the design of a bridge is no longer functionally adequate for its current use, such as a lack of shoulders or the inability to handle current traffic volumes. Functionally Obsolete does not directly relate to the structural adequacy.

The percentage of deck area on functionally obsolete bridges is calculated for each segment. The deck area for each bridge within each segment that has been identified as functionally obsolete will be totaled and divided by the total deck area for the segment to calculate the percentage of deck area on functionally obsolete bridges for each segment. Based on the data from the I-17, I-19, I-40, I-8, and SR 95 corridors, the thresholds for the Functionally Obsolete Bridges are as follows:

- Above average performance (Good): < 12%
- Average performance (Fair): 12% - 40%
- Below average performance (Poor): > 40%

Bridge Rating

The Bridge Rating simply identifies the lowest bridge rating on each segment. This performance measure is not an average and therefore is not weighted based on the deck area. The Bridge Index identifies the lowest rating for each bridge, as described above. This secondary performance measure will simply identify the lowest rating on each segment. Each of the four condition ratings uses a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. The performance thresholds for the Bridge Rating are as follows:

- Good: > 6
- Fair: 5 - 6
- Poor: < 5

Bridge Hot Spots

A bridge "hot spot" exists where a given bridge has a bridge rating of 4 or lower or multiple ratings of 5. This measure is mapped for graphical display purposes but is not included in the Bridge Performance Area rating calculations.

3.2.3 SR 95 Bridge Performance

The Bridge Index and Secondary Performance Measures were calculated for the SR 95 corridor using the Bridge Performance Area methodology (**Appendix B)**. ADOT provided the most recent bridge condition data from 2012 - 2014. The resulting scores are shown in **Table 4**. The results for the Bridge Index and the Secondary Measures are mapped in **Figure 9 – Figure 12**.

Based on the results of the analysis, the following bridge conditions were observed on SR 95:

- The weighted average of the Bridge Index indicates "fair" overall conditions for SR 95 bridges.
- All segments that contain bridges have a "fair" Bridge Index except Segment 9, which has a "good" Bridge Index.
- All segments that contain bridges have a "fair" Bridge Sufficiency except Segments 1 and 9, which have a "good" Bridge Index.
- There are two functionally obsolete bridges (in Segment 2 and Segment 12).
- All segments that contain bridges have a "fair" Bridge Rating.
- There are two bridge hot spots due to multiple 5 ratings. The hot spots are located in Segment 8 and Segment 12.

Table 4 - Bridge Performance Summary

Segment	Segment Length (miles)	Bridge Performance Area			
		Bridge Index	Bridge Sufficiency	% Bridges Functionally Obsolete	Bridge Rating
95-1	5	6.00	80.87	0.0%	6
95-2	9	6.00	78.12	8.5%	6
95-3	17	5.00	68.22	0.0%	5
95-4	20	No Bridges			
95-5	24	No Bridges			
95-6	2.5	6.00	76.00	0.0%	6
95-7	20	6.00	79.00	0.0%	6
95-8	11	5.00	67.00	0.0%	5
95-9	6	6.76	80.86	0.0%	6
95-10	14	6.25	78.25	0.0%	6
95-11	14	No Bridges			
95-12	14	5.46	76.82	20.2%	5
95-13	12	No Bridges			
Weighted Average		5.72	75.44	3.7%	6

Good	> 6.5	> 80	< 12%	> 6
Fair	5.0 - 6.5	50 - 80	12% - 40%	5 - 6
Poor	< 5.0	< 50	>40%	< 5

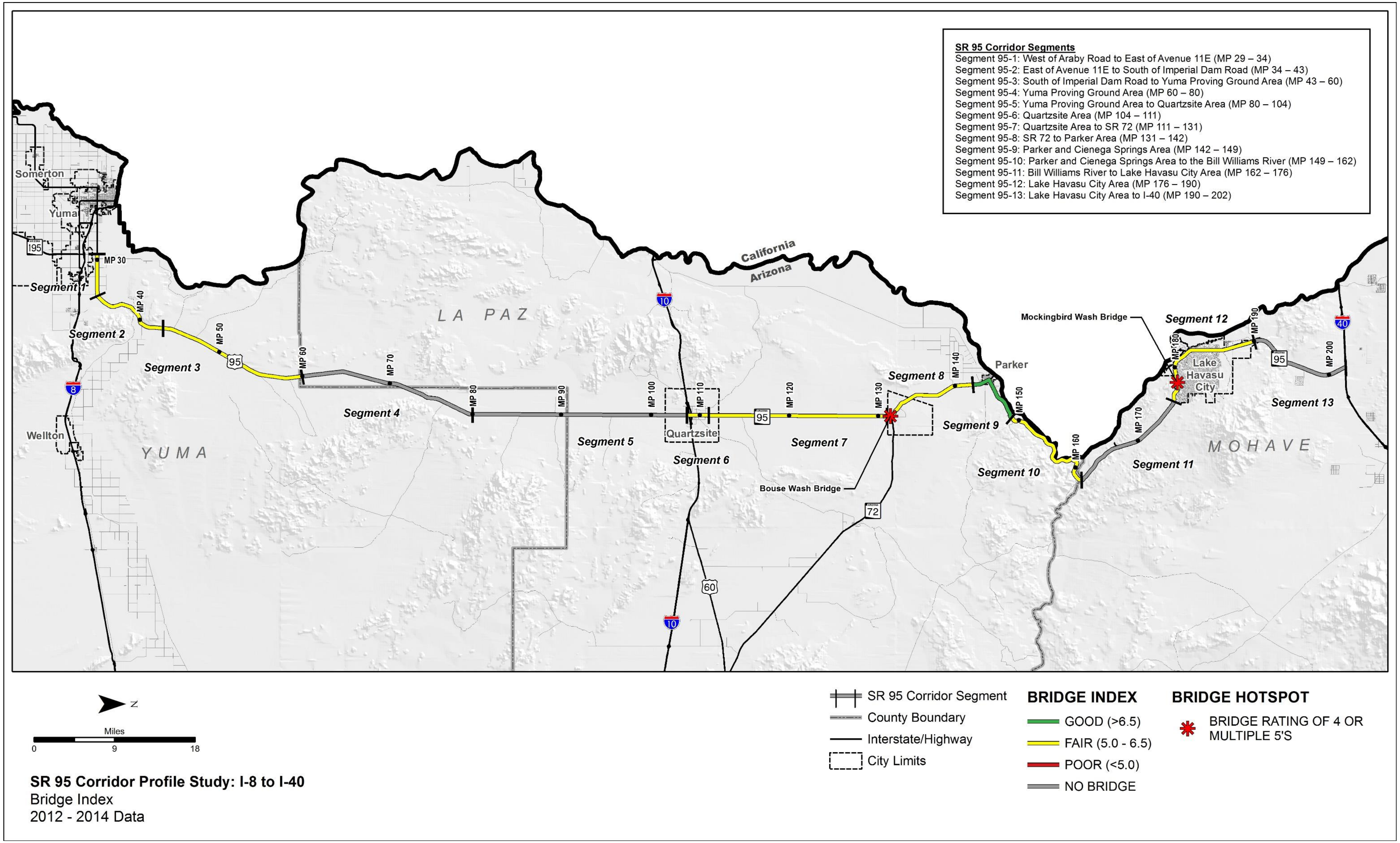


Figure 9 - Bridge Index

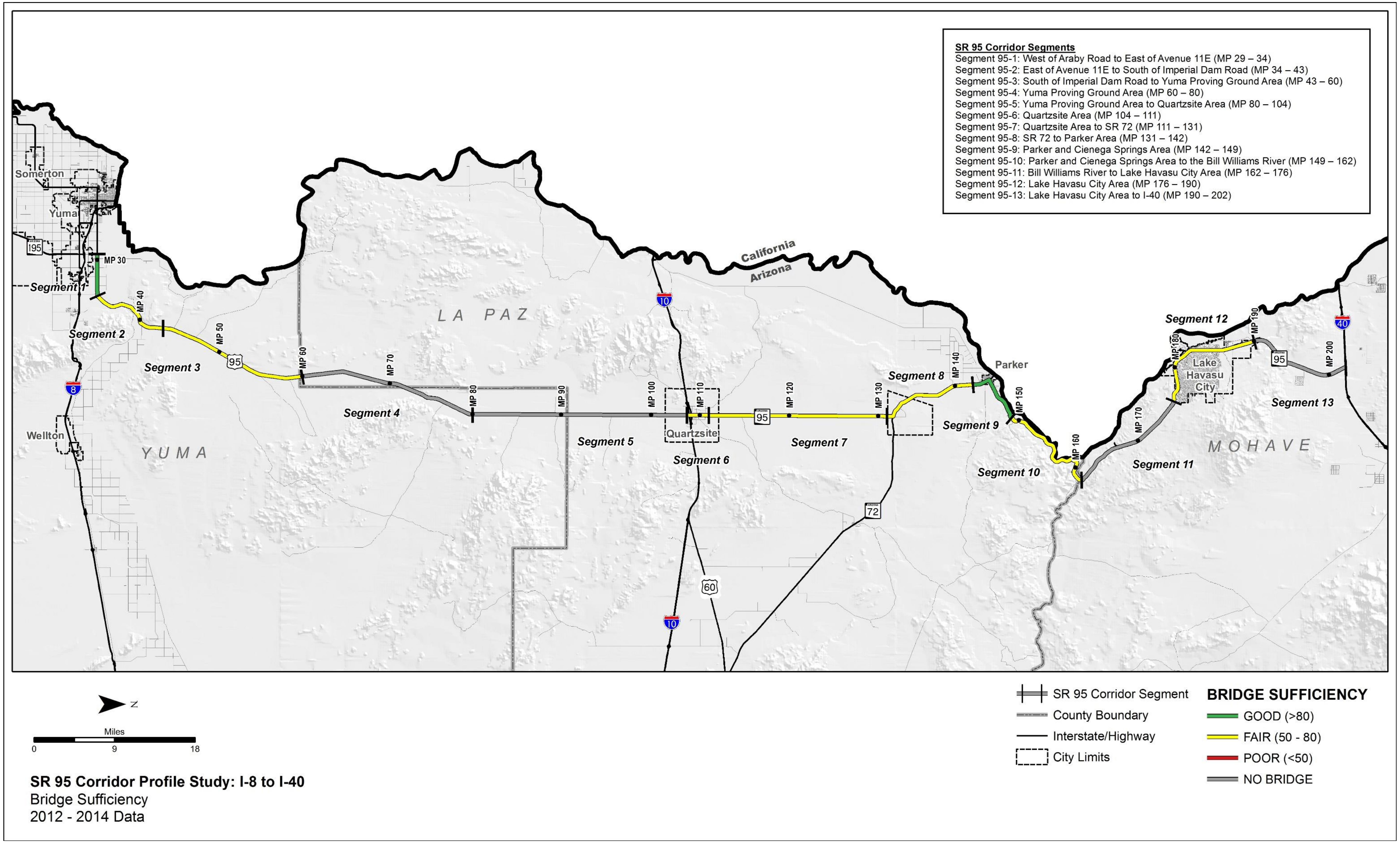


Figure 10 - Bridge Sufficiency

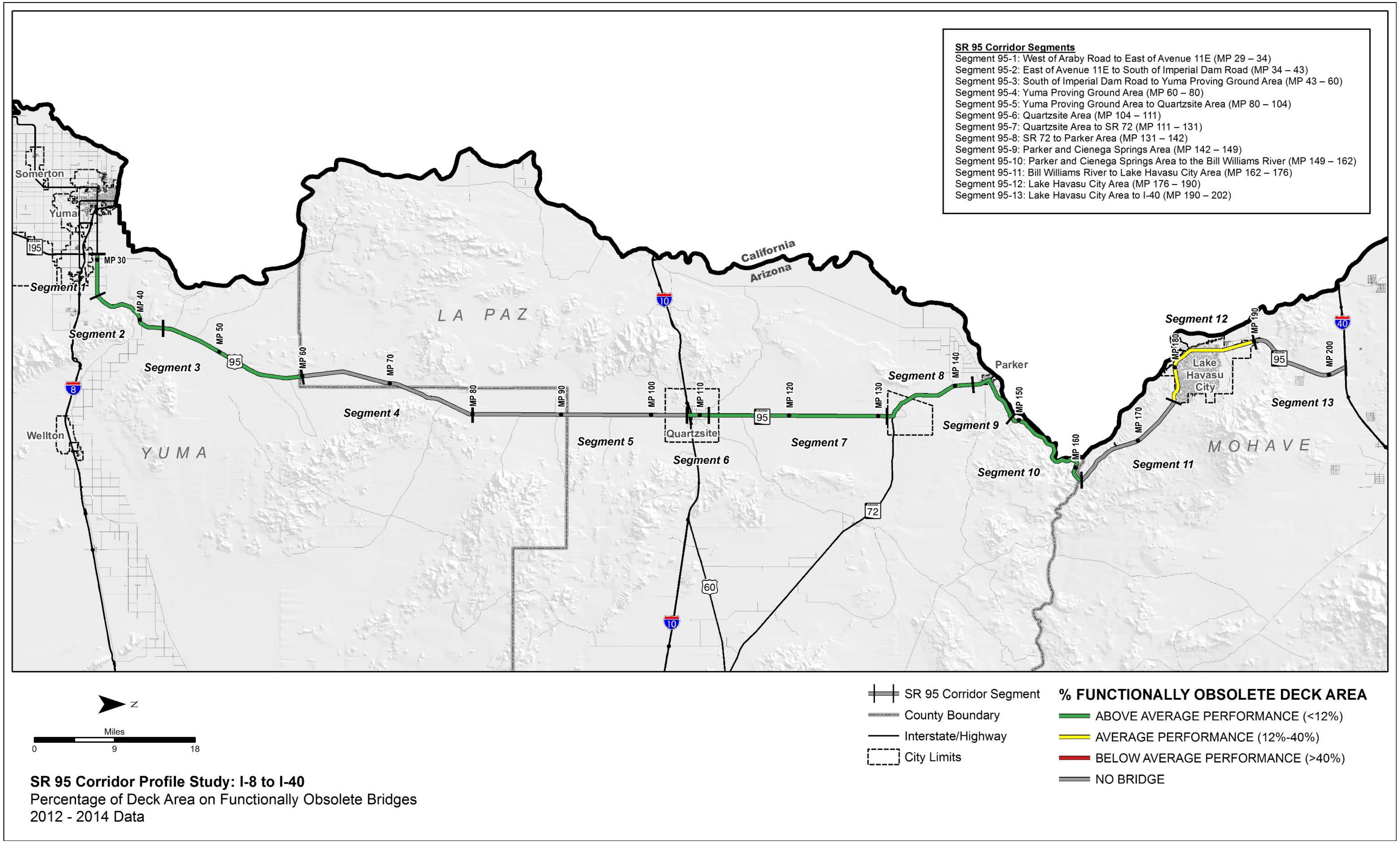


Figure 11 - Functionally Obsolete Bridges

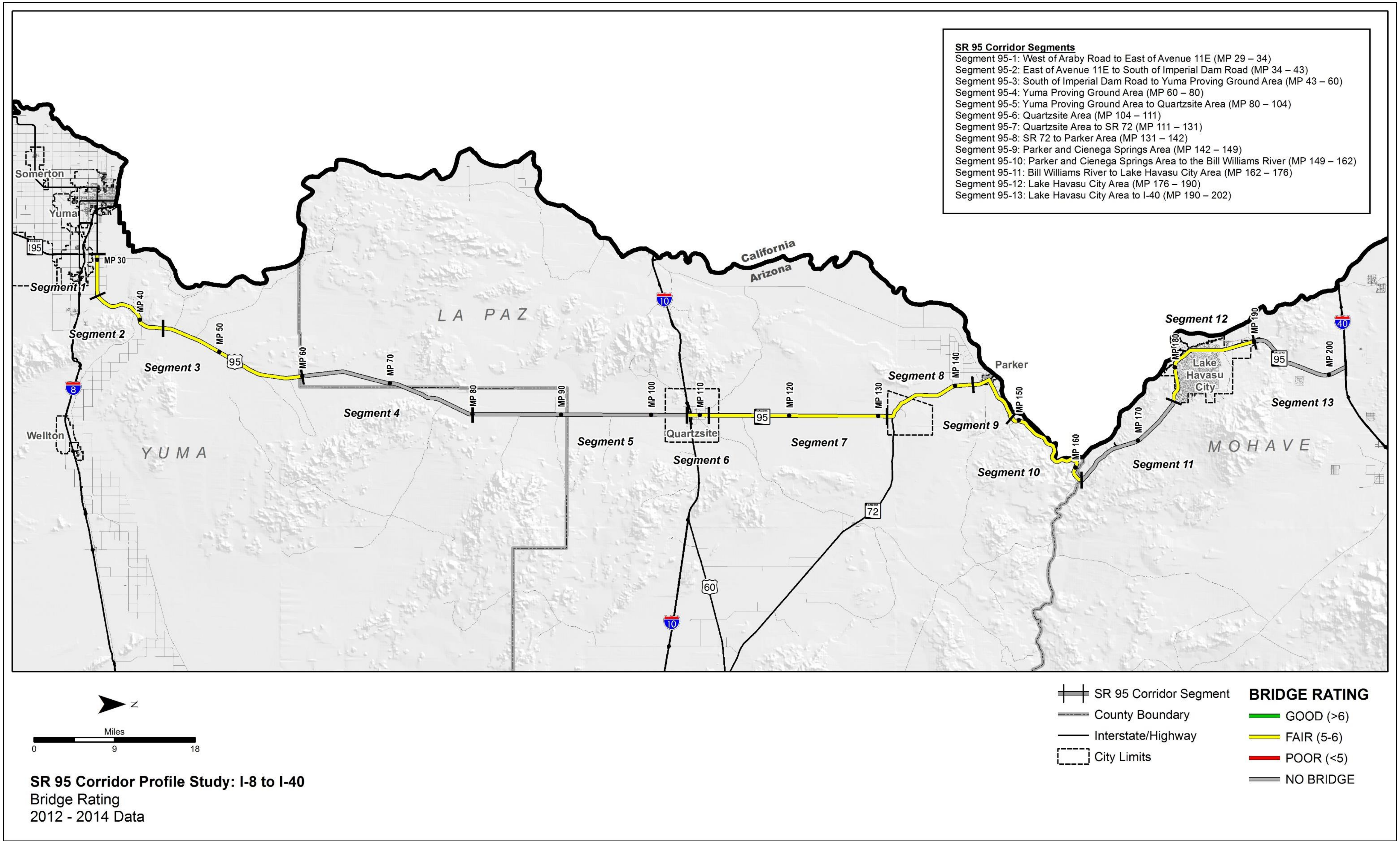


Figure 12 - Bridge Rating

3.3 Mobility Performance Area

The Mobility Performance Area consists of a single primary measure (Mobility Index) and multiple secondary measures, as shown in **Figure 13**, to assess levels and types of congestion that occur along the corridor using available data including annual average daily traffic (AADT), projected traffic volume growth from the Arizona Travel Demand Model (AZTDM), travel time, speed, and road closures. The Mobility Performance Area was developed in collaboration with ADOT Multimodal Planning Division, which is involved in maintaining the AZTDM and associated travel data. Detailed information related to the calculations for the Mobility Performance Area is included in **Appendix B** of this Working Paper.

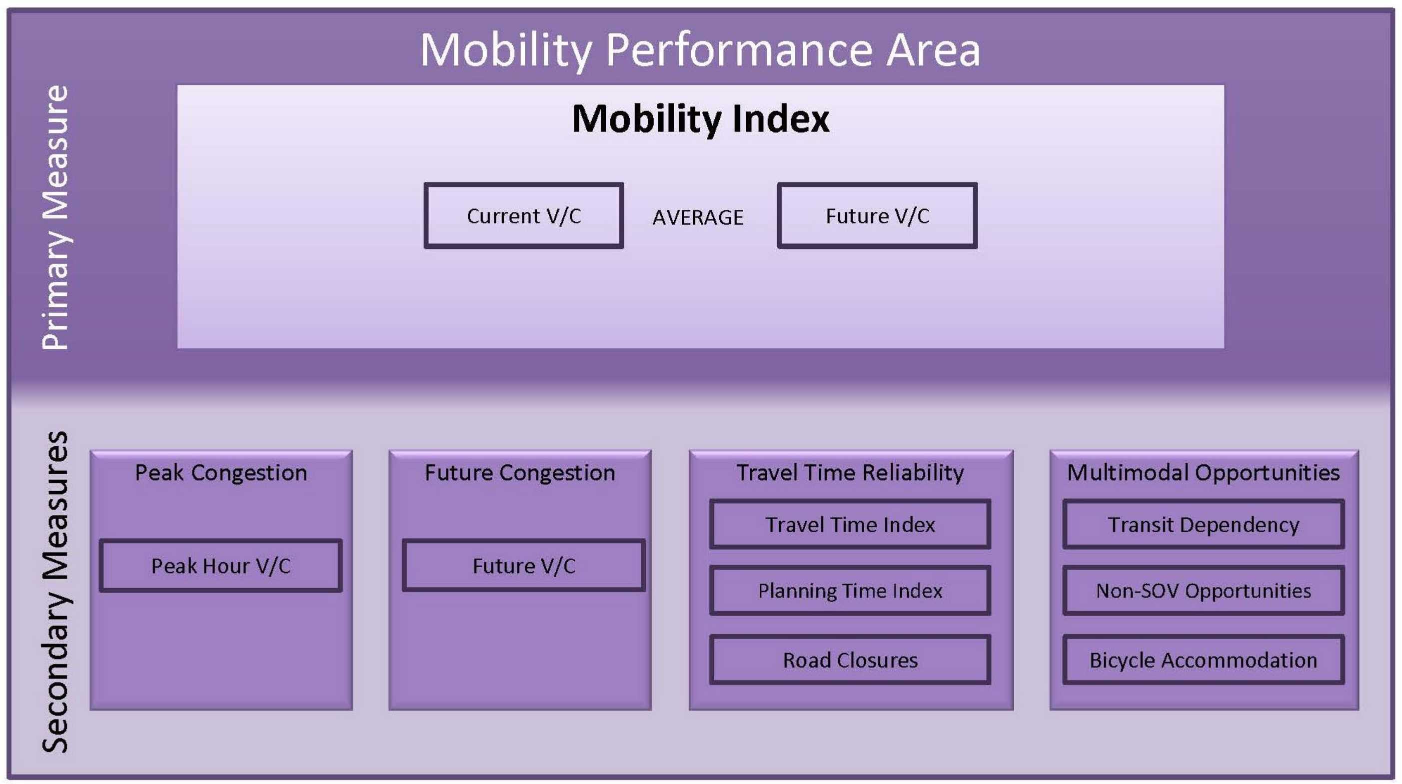


Figure 13 - Mobility Performance Area

3.3.1 Primary Measure: Mobility Index

The Mobility Index is an average of the current (2013) daily volume-to-capacity (V/C) ratio and the future (2035) daily V/C ratio for each segment of the corridor. V/C ratios are an indicator of levels of congestion. This measure compares the average AADT volume for a segment to the planning capacity of the segment as defined by the service volume for level of service E (LOS E). By using the average of the current and future year, this index measures the level of daily congestion that could occur in approximately ten years (2025) if no capacity improvements are made to the corridor.

Current Daily V/C Ratio

The current V/C ratio for each segment of SR 95 is calculated using the 2013 AADT volume and dividing that value by the service volume for LOS E, as calculated using the HERS Procedures for Estimating Highway Capacity. The HERS procedure provides the benefit of incorporating HCM 2010 methodologies while taking the context of the corridor into account. The capacity estimation procedures for various facility types are available including Freeways, Rural Two-Lane Highways, Multilane Highways, and Signalized Urban Sections.

AADT is obtained from the Highway Performance Monitoring System (HPMS) maintained by ADOT. Segment capacity is defined by the number of mainline lanes, shoulder widths, interrupted or uninterrupted flow facilities, terrain type, percent of truck traffic and the designated urban or rural environment.

Future Daily V/C Ratio

The future V/C ratio for each segment is calculated using the 2035 AADT volume and dividing that value by the service volume for LOS E, as estimated using the HERS procedure mentioned above. The 2035 AADT volumes are generated by applying an annual compound growth rate from the AZTDM to the 2013 AADT segment volume.

The scaling thresholds defined for the Mobility Index are based on the *ADOT Roadway Design Guidelines*, which define criteria for acceptable levels of service for the State Highway System. The following scaling thresholds are established for interstates in urban (and fringe urban) and rural environments.

Urban and Fringe Urban Environments

- Good (LOS A-C): < 0.71
- Fair (LOS D): 0.71 - 0.89
- Poor (LOS E-F): > 0.89

Rural Environments

- Good (LOS A-B): < 0.56
- Fair (LOS C): 0.56 - 0.76
- Poor (LOS D-F): > 0.76

3.3.2 Secondary Measures

The Mobility Performance Area has eight secondary measures:

- Peak Congestion – Current Peak Hour V/C
- Future Congestion – Future Daily V/C
- Travel Time Reliability – Directional Closures
- Travel Time Reliability – Directional Travel Time Index
- Travel Time Reliability – Directional Planning Time Index
- Multimodal Opportunities – Transit Dependency
- Multimodal Opportunities – Non-Single Occupancy Vehicle Trips
- Multimodal Opportunities – Bicycle Accommodation

Peak Congestion – Current Peak Hour V/C

Peak Congestion is defined as the peak hour V/C ratio for each direction of travel. The peak hour V/C is calculated by dividing the directional design hour volume (DHV) by the directional capacity. The DHV is calculated by applying a directional K factor to the directional daily AADT. K factors were obtained from HPMS.

The rating thresholds defined for the Peak Congestion secondary measure were developed based on the current *ADOT Roadway Design Guidelines* and are the same as the thresholds defined previously for the Mobility Index primary measure.

Future Congestion – Future Daily V/C

Future Congestion is defined as the future (2035) daily V/C ratio. This measure is the same value used in the calculation of the Mobility Index.

The rating thresholds defined for the Future Congestion secondary measure are developed based on the current *ADOT Roadway Design Guidelines* and are the same as the thresholds defined for the Mobility Index.

Travel Time Reliability – Directional Closures

Closures that occurred at any point along SR 95 from 2010-2014 are documented in ADOT's Highway Condition Reporting System (HCRS) dataset. Directional Closures are defined as the average number of times a milepost is closed per mile per year on a given segment of the corridor in a specific direction of travel. A weighted average was applied to each closure that takes into account the distance over which a specific occurrence spans.

The scaling thresholds defined for the Directional Closures secondary measure are based on the average number of times a milepost was closed per mile per year based on data of the following nine statewide significant corridors identified by ADOT: I-8, I-17, I-19, I-40, SR 93, SR 95, and parts of US 60, SR 87, SR 191, SR 260, SR 277, and SR 377. The following scaling thresholds represent the average for closure occurrences across those corridors:

- Good: < 0.38 occurrences per mile per year
- Fair: 0.38 – 1.46 occurrences per mile per year
- Poor: > 1.46 occurrences per mile per year

Travel Time Reliability – Directional Travel Time Index

For purposes of this performance measure, the Travel Time Index (TTI) is the relationship of the posted speed limit to the mean peak hour speed. The TTI is affected most by recurring congestion. It is a comparison between the peak period speeds and free-flow conditions. Using 2014 HERE data provided by ADOT, which includes data received via Bluetooth technology from motorists traveling throughout the SR 95 corridor, four time periods for each data point were collected throughout the day (AM Peak, Mid-Day Peak, PM Peak, and Off-peak). The highest value of the four time periods collected was defined as the TTI for that data point. The average TTI for each segment was calculated based on the average of the TTI values for the data points within that segment.

Based on national research and coordination with ADOT, the following thresholds were applied to the TTI:

Uninterrupted Flow Facilities

- Good: < 1.15
- Fair: 1.15 - 1.33
- Poor: > 1.15

Interrupted Flow Facilities

- Good: < 1.3
- Fair: 1.3 - 2.0
- Poor: > 2.0

Travel Time Reliability – Directional Planning Time Index

The Planning Time Index (PTI) represents the amount of time over and above the expected travel time that should be planned for to make an on-time trip on a consistent basis. It is a comparison between the 5th percentile lowest mean speeds to free-flow conditions. Similar to the TTI, the PTI utilizes 2014 HERE data provided by ADOT that is collected at each data point during four times of day (AM Peak, Mid-Day Peak, PM Peak, and Off-peak). The highest value of the four time periods collected was defined as the PTI for that data point. The average PTI for each segment was calculated based on the average of the PTI values for the data points within that segment.

Based on national research and coordination with ADOT, the following thresholds were applied to the PTI:

Uninterrupted Flow Facilities

- Good: < 1.3
- Fair: 1.3 - 1.5
- Poor: > 1.5

Interrupted Flow Facilities

- Good: < 2.0
- Fair: 2.0 - 4.0
- Poor: > 4.0

Multimodal Opportunities – Transit Dependency

Multimodal opportunities reflect the characteristics of the corridor in terms of likelihood to use alternate modes to the single occupancy vehicle for trips along the corridor. One of the potential alternate modes is transit.

Transit dependency was determined at the census tract level based on population characteristics associated with tracts within a one-mile radius of the corridor. Households that have zero or one automobile and households where the total income level is below the federally defined poverty level are considered transit dependent and therefore more likely to utilize transit if it is available. Based on 2010 U.S. Census data, tracts were analyzed within the corridor study area to determine if they accounted for more or fewer households with zero or one automobile or people in poverty than the statewide averages for those characteristics.

The rating thresholds defined for the overall transit dependency of each census tract are a combination of both transit dependent characteristics as follows:

- Good: Tracts with both zero/one automobile households and households in poverty percentages below the statewide average range
- Fair: Tracts with either zero/one vehicle household or households in poverty percentages within the statewide average range
- Poor: Tracts with both zero/one automobile households and households in poverty percentages above the statewide average range

Multimodal Opportunities – Non-Single Occupancy Vehicle Trips

Another multimodal opportunity is non-single occupancy vehicle (SOV) trips, which represent the trips that are taken by vehicles carrying more than one person as estimated by AZTDM. The percentage of non-SOV trips in a corridor gives an indication of travel patterns along a section of roadway that could benefit from additional multimodal options in the future.

The rating thresholds defined for non-SOV trips are based on the percentage of non-SOV trips across the previously identified nine ADOT statewide significant corridors. The following thresholds represent statewide averages of non-SOV trips across those corridors:

- Good: > 17% non-SOV trips
- Fair: 11% - 17% non-SOV trips
- Poor: < 11% non-SOV trips

Multimodal Opportunities – Bicycle Accommodation

Bicyclists may choose to utilize state highways or interstates (unless specifically prohibited) as a mode of travel. Thus, bicycle consideration is considered an important element of the Multimodal Opportunities provided by a corridor, particularly for non-interstate facilities. Using guidance from AASHTO, effective right-shoulder widths were defined based on shoulder characteristics as a function of the facility's posted speed limit and AADT. The corridor's shoulders are compared to the following criteria:

1. If AADT ≤ 1500 VPD Or Speed Limit ≤ 25 MPH: The segment's general purpose lane can be shared with Bicyclists
2. If AADT > 1500 And Speed Limit is between 25 – 50 MPH And Pavement Surface is Paved: Effective shoulder width required is 4 feet or greater
3. If AADT > 1500 And Speed Limit ≥ 50 MPH And Pavement Surface is Paved: Effective shoulder width required is 6 feet or greater

The summation of the length of the shoulder sections that meet the defined effective width criteria, based on criteria above, will be divided by the segments total length to estimate the percent of the segment that accommodates bicycle use. The performance thresholds are as followed:

- Good: > 90%
- Fair: 60% - 90%
- Poor: < 60%

3.3.3 SR 95 Mobility Performance

The Mobility Index and Secondary Performance Measures were calculated for the SR 95 corridor using the Mobility Performance Area methodology (**Appendix B)**. The calculations were based on data provided by ADOT which include the HPMS system for the year 2013, the AZTDM for the years 2010 and 2035, HERE data from 2014, and closure data from 2010 – 2014. The resulting scores are shown in **Table 5.** The results for the Mobility Index and the Secondary Measures are mapped in **Figure 14 – Figure 21**.

Based on the results of the analysis, the following Mobility conditions were observed on SR 95:

- The weighted average of the Mobility Index indicates "good" overall mobility conditions for SR 95 with Segment 12, Lake Havasu City segment, indicating "fair" conditions
- During the existing peak hour, traffic operations are "good" for all segments.
- Segment 12 is anticipated to have "poor" performance in the future, according to the Future V/C performance measure.
- The TTI measure indicates that the SR 95 segments generally have "good" performance. Segment 12 within Lake Havasu City has the highest TTI.
- The PTI measure indicates many of the SR 95 segments, both northbound and southbound, have "fair" or "poor" performance in terms of reliability. Segments 4, 6, 9, and 12 have the least reliable travel time.
- More than half of SR 95 segments show "poor" or "fair performance for non-SOV trips, indicating single occupant trips are more common. Overall, the corridor's weighted average performance regarding non-SOV trips is "fair".
- Segments 9 and 12 have "fair" performance in the closure duration performance measure. The overall weighted average for closures show "good" performance for the corridor.
- Overall, the SR 95 corridor has "poor" performance for accommodating bicycle travel along SR 95.

Table 5 - Mobility Performance Summary

Segment	Segment Length (miles)	Mobility Index	Future Daily V/C	Existing Peak Hour V/C NB	Existing Peak Hour V/C SB	Closure Extent (instances/ milepost/year/mile) NB	Closure Extent (instances/ milepost/year/mile) SB	Directional TTI (all vehicles) NB	Directional TTI (all vehicles) SB	Directional PTI (all vehicles) NB	Directional PTI (all vehicles) SB	% Non-Single Occupancy Vehicle (SOV) Opportunities	% Bicycle Accommodation
95-1	5	0.43	0.51	0.33	0.30	0.32	0.28	1.07	1.10	2.99	3.71	18.6%	62%
95-2	9	0.31	0.37	0.22	0.22	0.18	0.13	1.03	1.03	2.18	1.30	19.8%	56%
95-3	17	0.10	0.12	0.10	0.10	0.02	0.06	1.03	1.03	1.27	1.28	19.8%	8%
95-4	20	0.12	0.14	0.08	0.07	0.05	0.01	1.18	1.06	5.36	1.42	5.0%	0%
95-5	24	0.12	0.14	0.08	0.08	0.05	0.04	1.02	1.08	1.17	1.56	23.0%	2%
95-6	2.5	0.48	0.63	0.31	0.35	0.24	0.08	1.06	1.39	4.79	5.98	24.6%	87%
95-7	20	0.16	0.22	0.09	0.10	0.14	0.10	1.06	1.04	1.28	1.37	14.6%	0%
95-8	11	0.32	0.43	0.17	0.17	0.13	0.05	1.08	1.04	1.90	1.45	9.1%	25%
95-9	6	0.57	0.62	0.45	0.42	0.43	0.37	1.08	1.06	5.41	3.58	11.4%	61%
95-10	14	0.21	0.23	0.18	0.10	0.21	0.17	1.04	1.04	1.38	1.33	2.2%	2%
95-11	14	0.16	0.18	0.13	0.09	0.33	0.27	1.04	1.01	1.30	1.38	8.3%	0%
95-12	14	0.78	1.02	0.53	0.52	0.43	0.43	1.32	1.23	4.98	3.89	18.1%	9%
95-13	12	0.22	0.26	0.16	0.15	0.27	0.32	1.05	1.08	3.33	3.93	14.3%	71%
Weighted Average		0.24	0.30	0.17	0.16	0.17	0.15	1.05	1.03	2.46	1.93	13.5%	17%

	Urban		Uninterrupted			
Good	< 0.71	< 0.38	< 1.15	< 1.3	> 17%	> 90%
Fair	0.71 - 0.89	0.38 - 1.46	1.15 - 1.33	1.3 - 1.5	11% - 17%	60% - 90%
Poor	> 0.89	> 1.46	> 1.33	> 1.5	< 11%	< 60%

	Rural		Interrupted			
Good	< 0.56	< 0.38	< 1.3	< 2.0	> 17%	> 90%
Fair	0.56 - 0.76	0.38 - 1.46	> 1.3 & < 2.0	> 2.0 & < 4.0	11% - 17%	60% - 90%
Poor	> 0.76	> 1.46	> 2.0	> 4.0	< 11%	< 60%

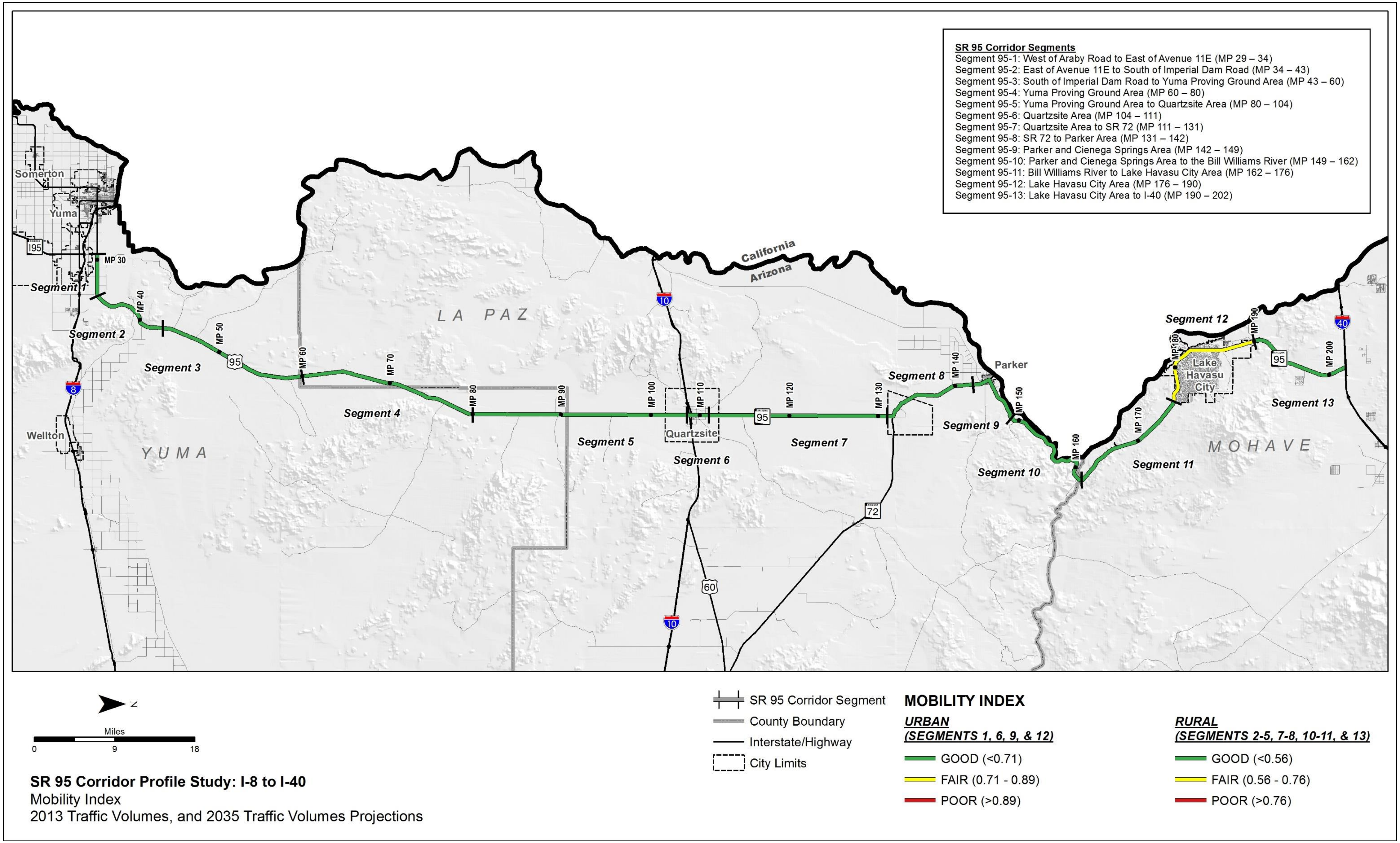


Figure 14 - Mobility Index

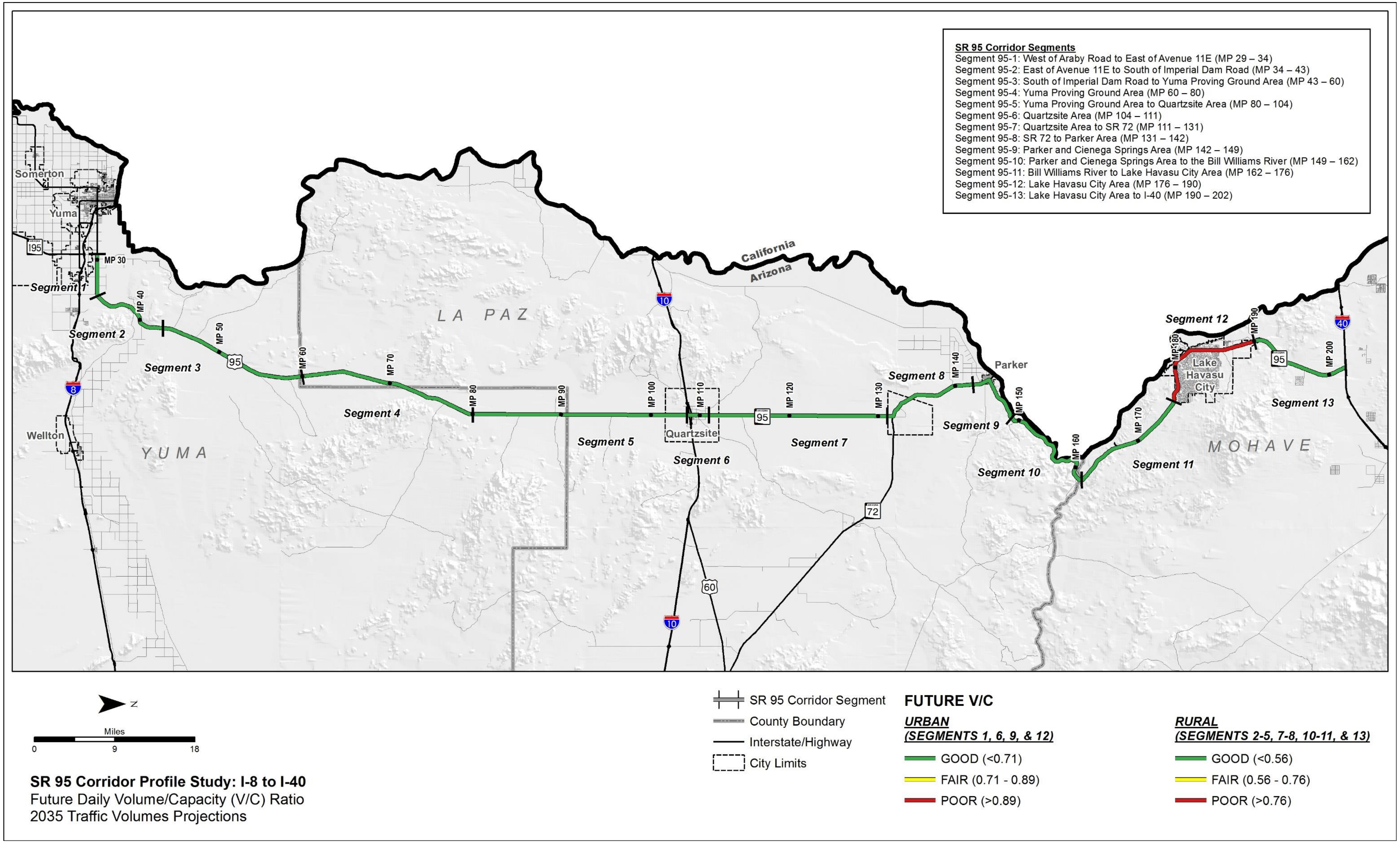


Figure 15 - Future Mobility

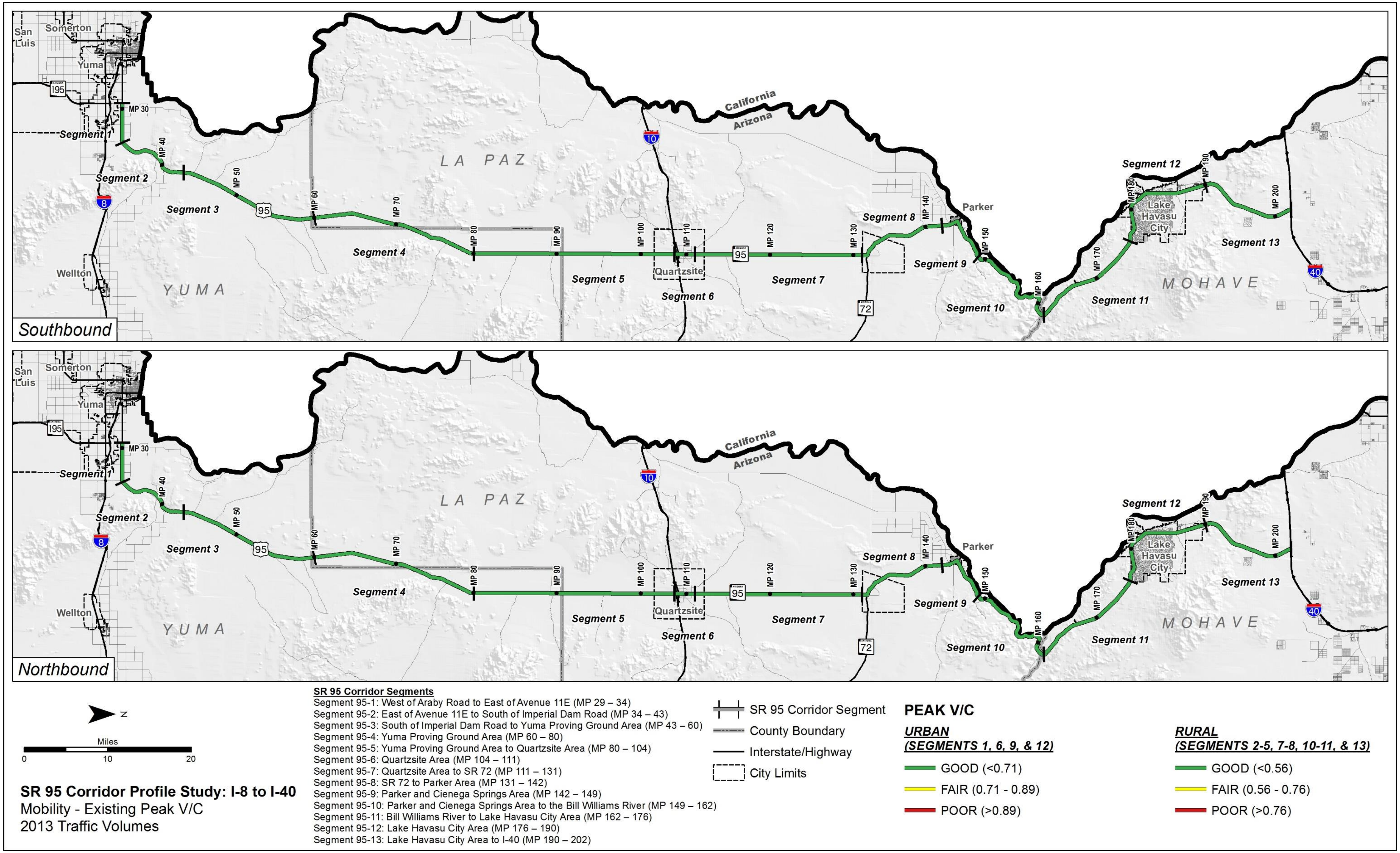


Figure 16 - Existing Peak Hour V/C

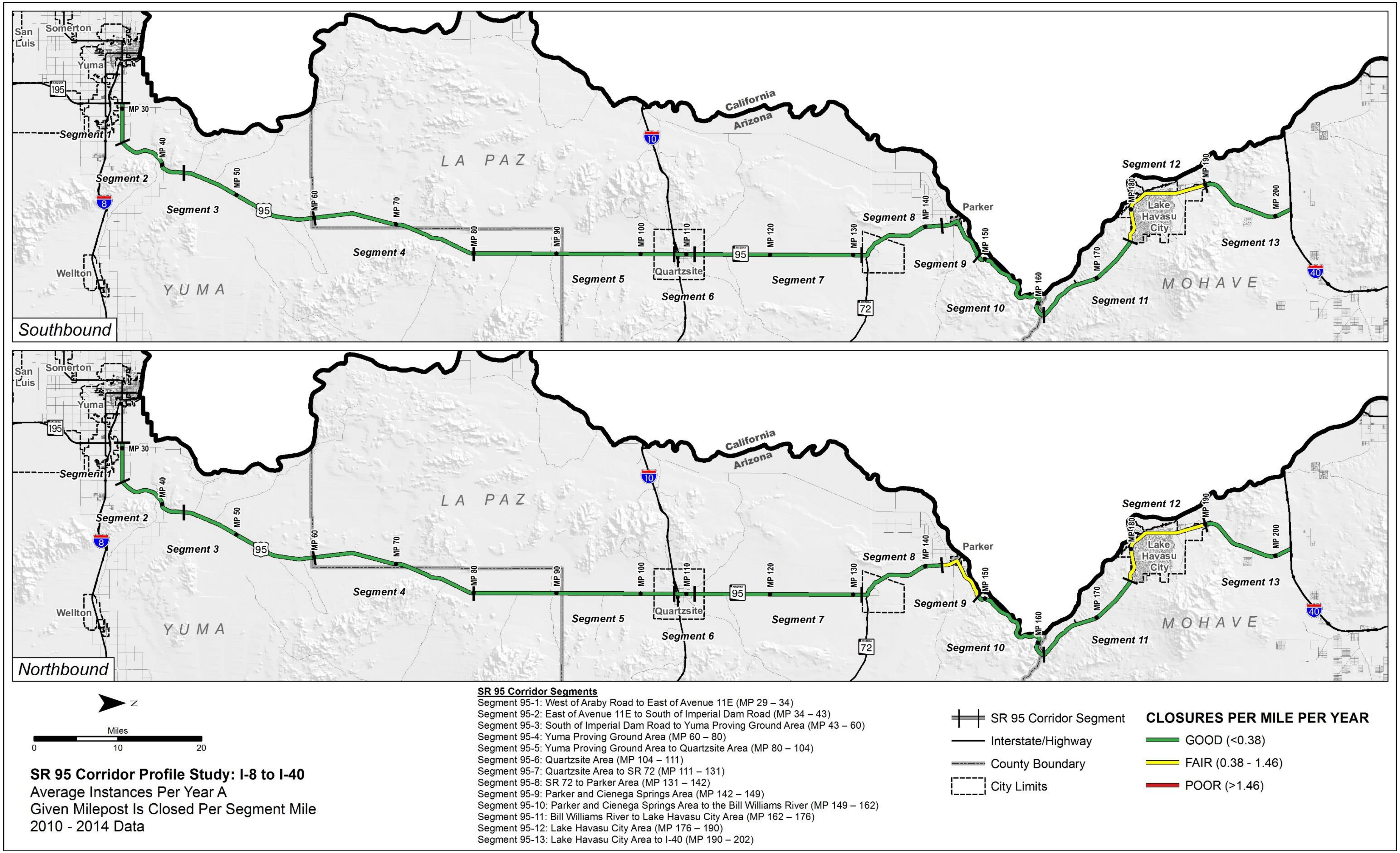


Figure 17 - Closures in Occurrences per Year per Mile Compared to State Average

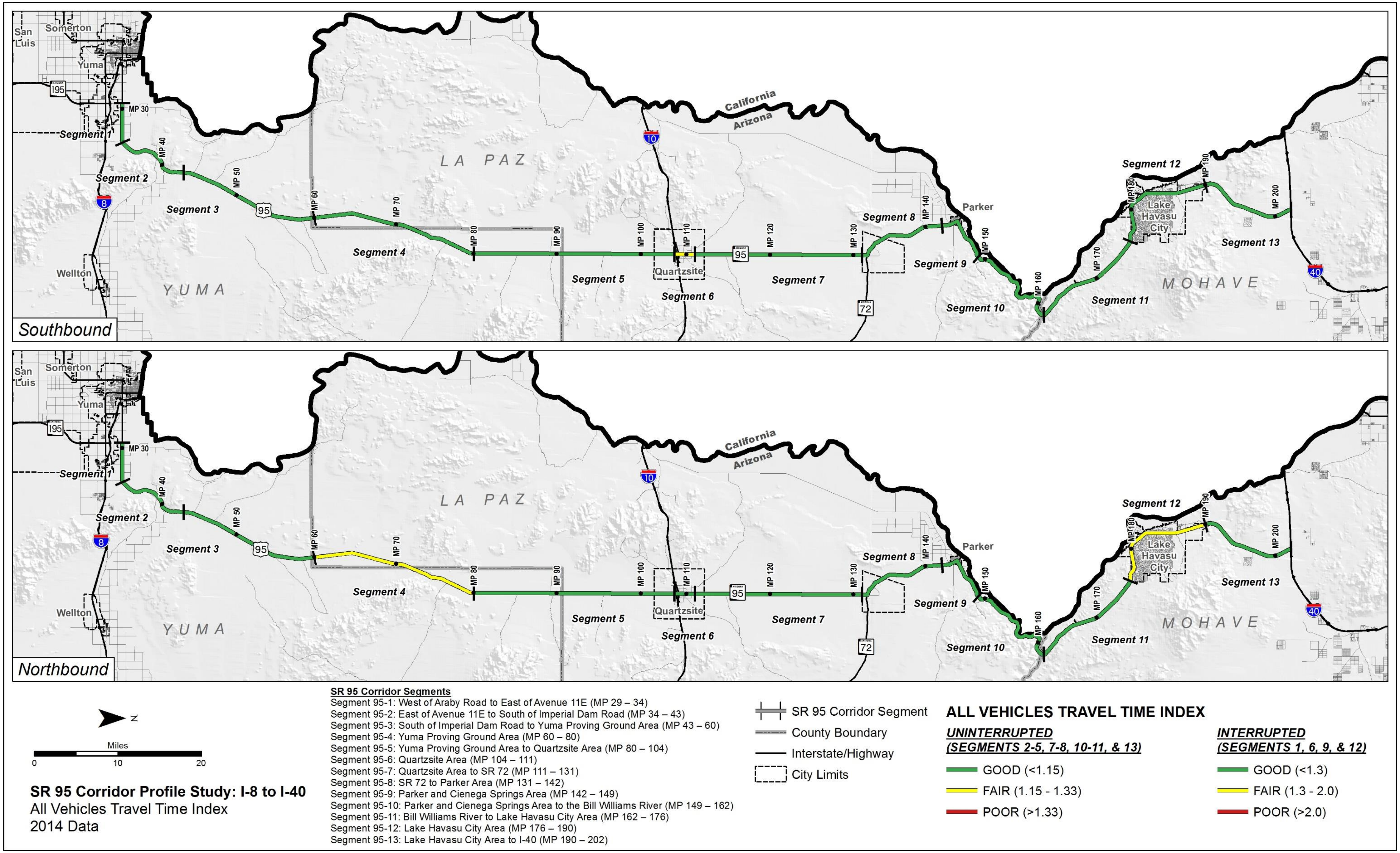


Figure 18 - All Vehicles Travel Time Index

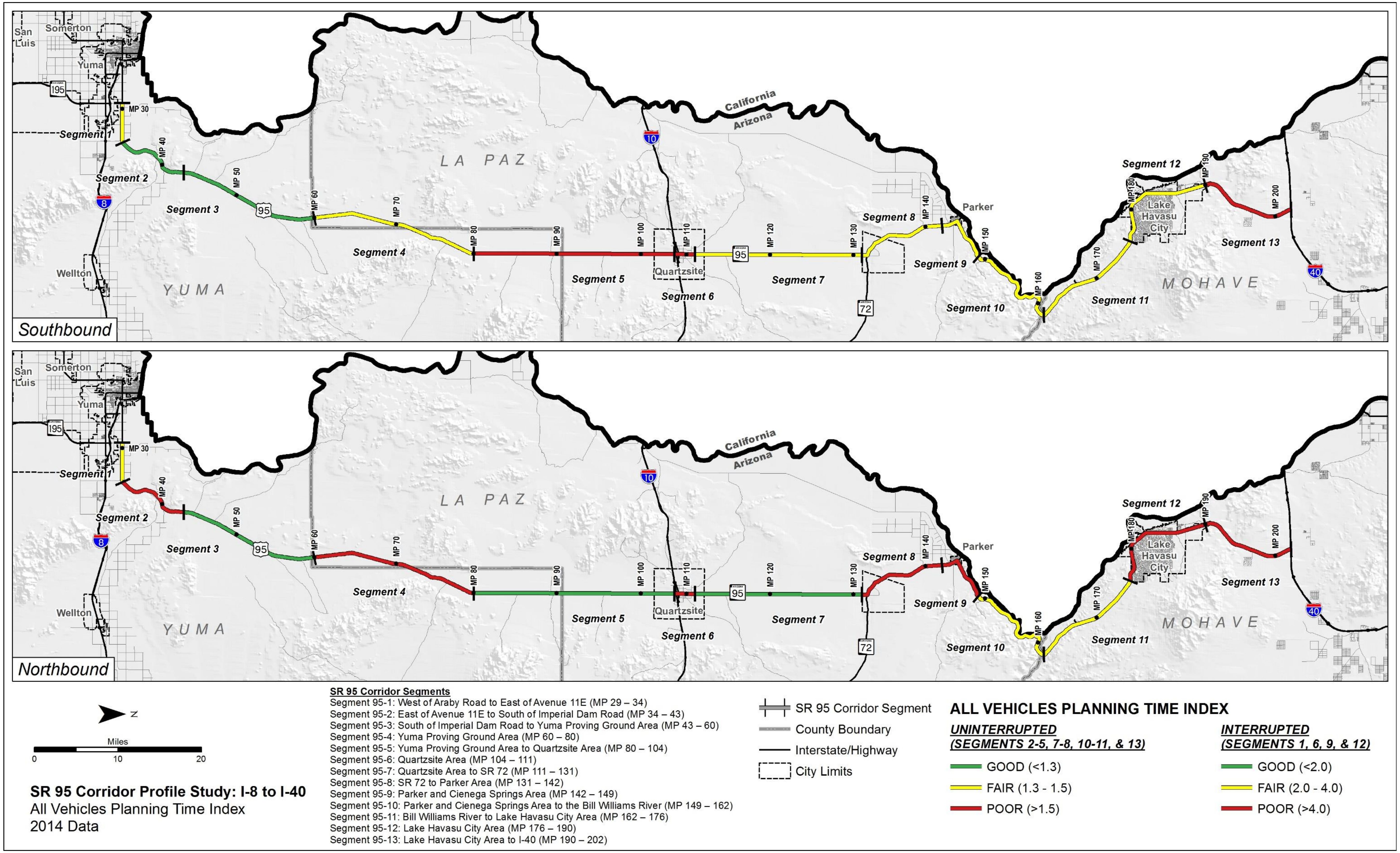


Figure 19 - All Vehicles Planning Time Index

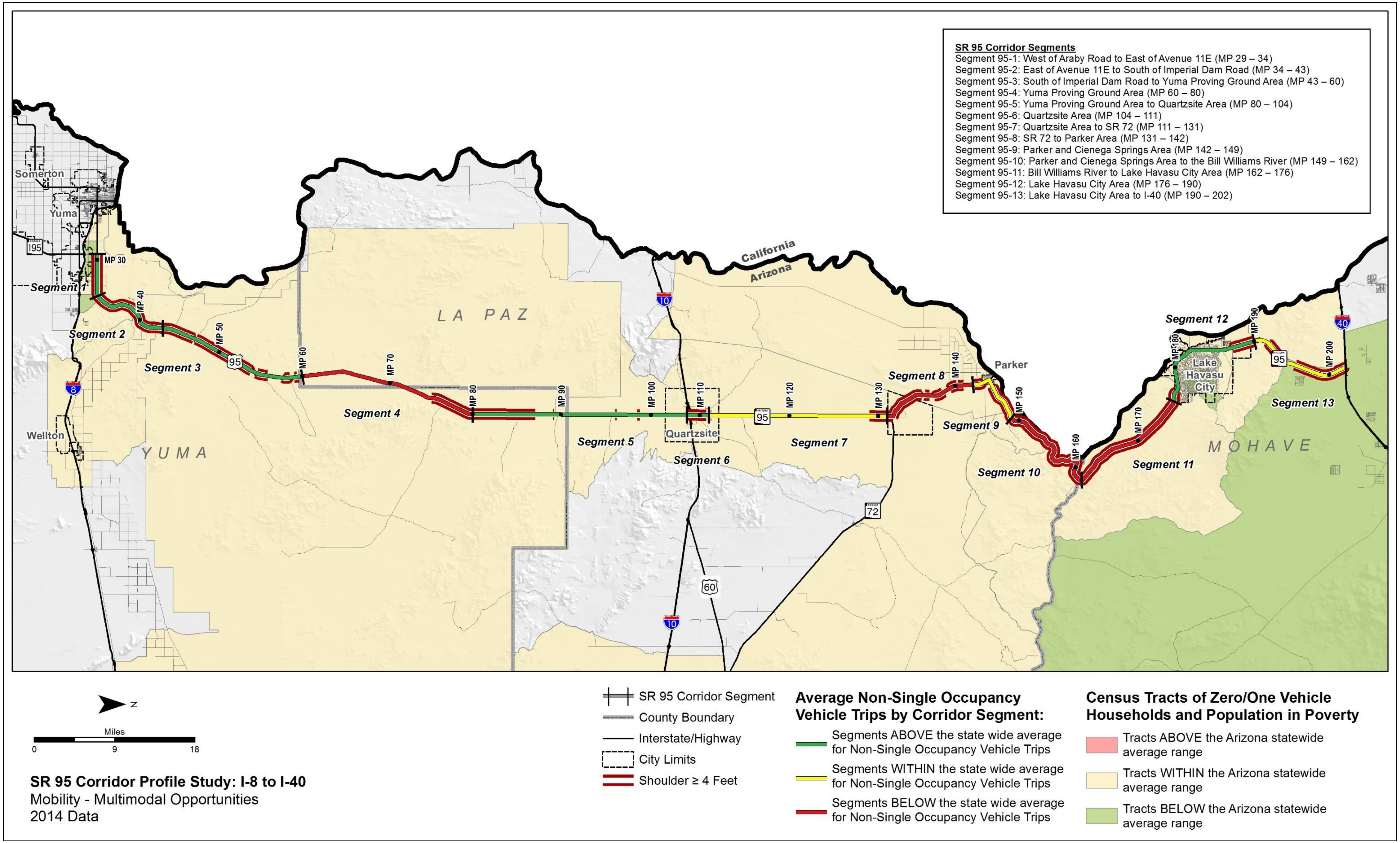


Figure 20 - Multimodal Opportunities

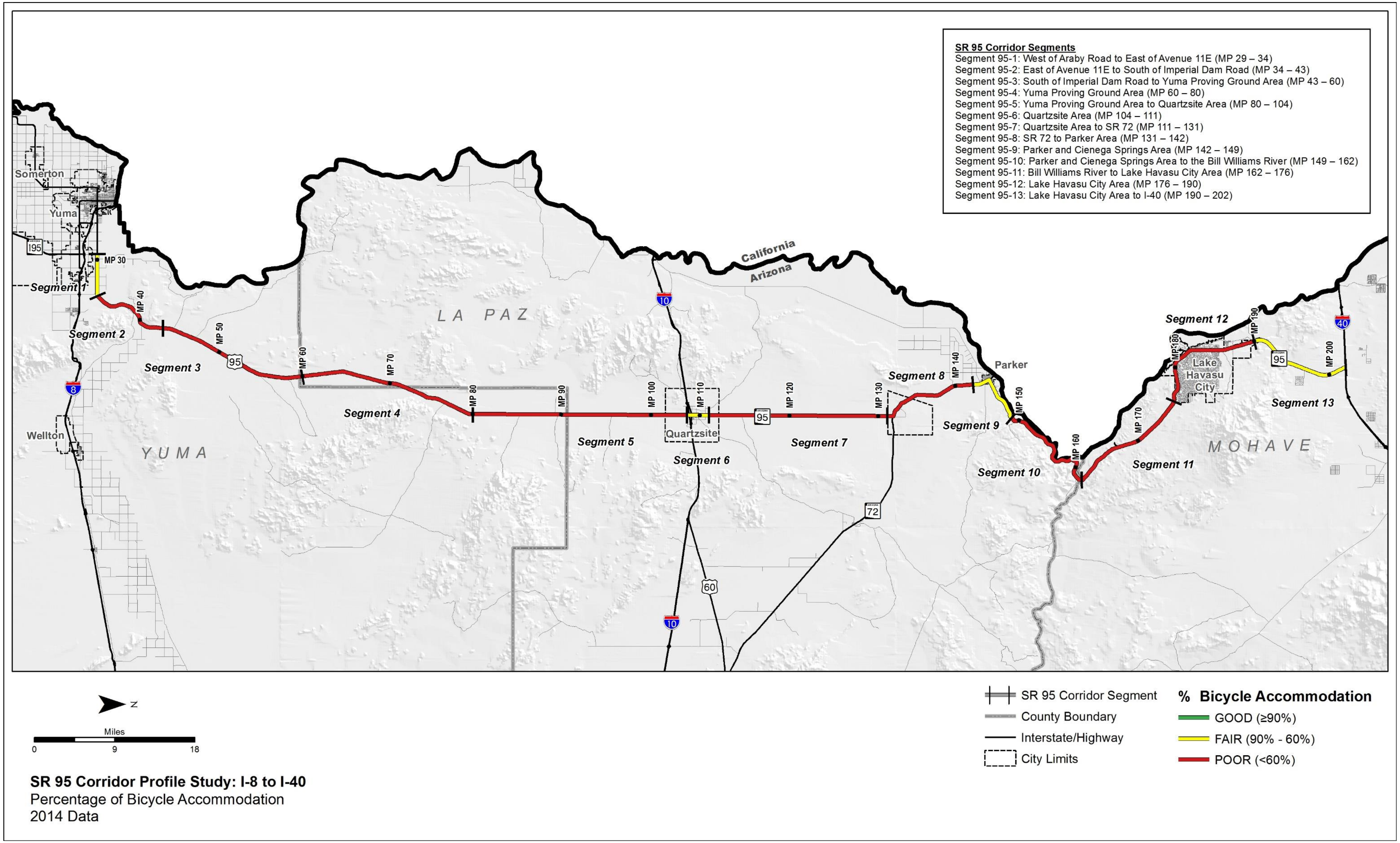


Figure 21 - Percent Bicycle Accommodation

3.4 *Safety Performance Area*

The safety performance area consists of a single Safety Index and four secondary measures as illustrated in **Figure 22**. All measures relate to crashes that result in fatal and incapacitating injuries, as these crash types are the emphasis of ADOT and MAP-21. The Safety Performance Area was developed in collaboration with ADOT's Traffic Safety Section. Detailed information related to the calculations for the Safety Performance Area is included in **Appendix B** of this Working Paper.

Figure 22 - Safety Performance Area Measures

3.4.1 Primary Measure: Safety Index

The Safety Index is a safety performance measure based on the bi-directional (i.e., both directions combined) frequency and rate of fatal and incapacitating injury crashes, the relative cost of those types of crashes, and crash occurrences on similar roadways in Arizona. According to ADOT's 2010 Highway Safety Improvement Program Manual, fatal crashes have an estimated cost that is 14.5 times the estimated cost of incapacitating injury crashes ($5.8 million compared to $400,000).

The Combined Safety Score (CSS) is an interim measure that combines fatal and serious injury crashes into a single value. The CSS is calculated using the following generalized formula:

*CSS = 14.5 * (Normalized Fatal Crash Rate + Frequency) + (Normalized Incapacitating Injury Crash Rate + Frequency)*

Because crashes vary depending on the operating environment of a particular roadway, statewide CSS values were developed for similar operating environments defined by functional classification, urban vs. rural setting, number of travel lanes, and traffic volumes. To determine the Safety Index of a particular SR 95 segment, the segment CSS was compared to the average statewide CSS for the similar statewide operating environment. For SR 95, two operating environments were identified:

- 2 or 3 Lane Undivided Highway
- 4 or 5 Lane Undivided Highway

The Safety Index is calculated using the following formula:

Safety Index = Segment CSS / Statewide Similar Operating Environment CSS

The average annual Safety Index for a segment is compared to the statewide similar operating environment annual average, with one standard deviation from the statewide average forming the scale break points.

The more a particular segment's Safety Index value is below the statewide similar operating environment average, the better the safety performance is for that particular segment as a lower value represents fewer crashes.

The scale for rating the Safety Index depends on the operating environments selected for a particular corridor. For SR 95, the scales for rating the Safety Index are:

2 or 3 Lane Undivided Highway

- Above average performance: < 0.94
- Average performance: 0.94 - 1.06
- Below average performance: > 1.06

4 or 5 Lane Undivided Highway

- Above average performance: < 0.80
- Average performance: 0.80 - 1.20
- Below average performance: > 1.20

3.4.2 Secondary Measures

The Safety Performance Area has four secondary measures related to fatal and incapacitating injury crashes:

- Directional Safety Index
- *Strategic Highway Safety Plan* (SHSP) Behavior Emphasis Areas
- SHSP Crash Unit Type Emphasis Areas
- Safety Hot Spots

The SHSP behavior emphasis areas and SHSP crash unit type emphasis areas secondary safety performance measures for the Safety Performance Area include proportions of specific types of crashes within the total fatal and incapacitating injury crash frequencies. This more detailed categorization of fatal and incapacitating injury crashes can result in low crash frequencies (i.e., a small sample size) that translate into performance ratings that can be unstable. In some cases, a change in crash frequency of one crash (one additional crash or one less crash) could result in a change in segment performance of two levels. To avoid reliance on performance ratings where small changes in crash frequency result in large changes in performance, the following criteria were developed to identify segments with "insufficient data" for assessing performance for the two SHSP-related secondary safety performance measures:

- If the crash sample size (total fatal plus incapacitating injury crashes) for a given segment is less than five crashes over the five-year analysis period, the segment has "insufficient data" and performance ratings are unreliable.
- If a change in one crash on a segment results in a change in segment performance of two levels (i.e., a change from below average to above average frequency or a change from above average to below average frequency), the segment has "insufficient data" and performance ratings are unreliable.
- If the corridor average segment crash frequency for a specific SHSP-related secondary safety performance measure type is less than two crashes over the five-year analysis period, the entire SHSP-related secondary performance measure has "insufficient data" and performance ratings are unreliable.

Directional Safety Index

The Directional Safety Index shares the same calculation procedure and thresholds as the Safety Index. However, the measure is based on the directional frequency and rate of fatal and incapacitating injury crashes.

Similar to the Safety Index, the segment CSS was compared to the average statewide CSS for the similar statewide operating environment.

SHSP Behavior Emphasis Areas

ADOT's 2014 SHSP identifies several emphasis areas for reducing fatal and incapacitating injury crashes. The top five SHSP emphasis areas relate to the following driver behaviors:

- Speeding and aggressive driving
- Impaired driving
- Lack of restraint usage
- Lack of motorcycle helmet usage
- Distracted driving

To develop a performance measure that reflects these five emphasis areas, the percentage of total fatal and incapacitating injury crashes that involves at least one of the emphasis area driver behaviors on a particular segment is compared to the statewide average percentage of crashes involving at least one of the emphasis area driver behaviors on roads with similar operating environments in a process similar to how the Safety Index is developed.

To increase the crash sample size for this performance measure, the five behavior emphasis areas are combined to identify fatal and incapacitating injury crashes that exhibit one or more of the five behavior emphasis areas.

The SHSP behavior emphasis areas performance is calculated using the following formula:

% Crashes Involving SHSP Behavior Emphasis Areas = Segment Crashes Involving SHSP Behavior Emphasis Areas / Total Segment Crashes

The percentage of total crashes involving SHSP behavior emphasis areas for a segment is compared to the statewide percentages on roads with similar operating environments. One standard deviation from the statewide average percentage forms the scale break points.

When assessing the performance of the SHSP behavior emphasis areas, the more the frequency of crashes involving SHSP behavior emphasis areas is below the statewide average implies better levels of segment performance. Thus, lower values are better, similar to the Safety Index.

The scale for rating the SHSP behavior emphasis areas performance depends on the crash history on similar statewide operating environments. In the case of the SR 95 corridor, the scales for rating the SHSP behavior emphasis areas performance are:

2 or 3 Lane Undivided Highway Segments

- Above average performance: > 51%
- Average performance: 51% - 57%
- Below average performance: < 57%

4 or 5 Lane Undivided Highway Segments

- Above average performance: > 42%
- Average performance: 42% - 51%
- Below average performance: < 51%

For SR 95, it was determined that five of the thirteen segments have insufficient data (i.e., too small of a sample size) to generate reliable performance ratings.

SHSP Crash Unit Type Emphasis Areas

ADOT's SHSP also identifies emphasis areas that relate to the following "unit-involved" crashes:

- Heavy vehicle (trucks)-involved crashes
- Motorcycle-involved crashes
- Non-motorized (pedestrian and bicyclist)-involved crashes

To develop a performance measure that reflects the aforementioned crash unit type emphasis areas, the percentage of total fatal and incapacitating injury crashes that involves a given crash unit type emphasis area on a particular segment is compared to the statewide average percentage of crashes involving that same crash unit type emphasis area on roads with similar operating environments in a process similar to how the Safety Index is developed.

Application of the above crash sample size criteria determined that the performance rating of several segments for the truck-involved crashes have insufficient data. The criteria also determined that motorcycle-involved and non-motorized traveler-involved crashes have an average segment crash frequency of less than 2 crashes over the five year analysis period and the entire performance measures removed from further consideration.

The SHSP crash unit type emphasis areas performance is calculated using the following formula:

% Crashes Involving SHSP Crash Unit Type Emphasis Areas = Segment Crashes Involving SHSP Crash Unit Type Emphasis Areas / Total Segment Crashes

The percentage of total crashes involving SHSP crash unit type emphasis areas for a segment is compared to the statewide percentages on roads with similar operating environments. One standard deviation from the statewide average percentage forms the scale break points.

When assessing the performance of the SHSP crash unit type emphasis areas, the more the frequency of crashes involving SHSP crash unit type emphasis areas is below the statewide average implies better levels of segment performance. Thus, lower values are better, similar to the Safety Index.

The scale for rating the SHSP crash unit type emphasis areas performance depends on the crash history on similar statewide operating environments. For SR 95, it was determined that the SHSP crash unit type performance measures for crashes involving heavy vehicle (trucks), motorcycles, and non-motorized travelers have insufficient data (i.e., too small of a sample size) to generate reliable performance ratings so these secondary safety performance measures were removed from the performance evaluation.

Safety Hot Spots

A "hot spot" analysis was conducted that identified abnormally high concentrations of fatal and incapacitating injury crashes along the study corridor by direction of travel. The identification of crash concentrations involves a geographic information system (GIS)-based function known as "kernel density analysis". The size of an identified hot spot is indicative of its relative magnitude. This measure is mapped for graphical display purposes but is not included in the Safety Performance Area rating calculations.

3.4.3 SR 95 Safety Performance

The Safety Index and Secondary Performance Measures were calculated for the SR 95 corridor using the Safety Performance Area methodology (**Appendix B)**. The calculations were based on crash data provided by ADOT from 2010 - 2014. The resulting scores are shown in **Table 6**. The results for the Safety Index and the Secondary Measures are mapped in **Figure 23 – Figure 26**.

Based on the results of the analysis, the following Safety conditions were observed on SR 95:

- A total of 159 fatal and incapacitating injury crashes occurred along the SR 95 corridor in 2010 - 2014. Of these crashes, 24 were fatal and 135 involved incapacitating injuries.
- The weighted average of the corridor Safety Index indicates it is "above average" compared to other segments statewide that have similar operating environments, meaning the corridor generally performs well as it relates to safety.
- The Safety Index value for Segments 2, 4, 6, 11, and 12 is "below average", meaning these segments have more crashes than is typical statewide.
- The Directional Safety Index value for Segments 2, 4, 5, 6, 9, 11, 12, and 13 is "below average", meaning these segments have more crashes than is typical statewide.
- The percentage of crashes related to the SHSP top 5 emphasis areas is higher in Segments 8 and 11 than the statewide average for similar operating environments.
- Crashes have occurred more frequently northbound than southbound.

Table 6 - Safety Performance Summary

Segment	Segment Length (miles)	Safety Performance Area			
		Safety Index	NB Directional Safety Index	SB Directional Safety Index	% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors
95-1	5	1.13	1.13	1.13	17%
95-2	9	1.29	2.43	0.16	Insufficient Data
95-3	17	0.06	0.11	0.00	Insufficient Data
95-4	20	1.48	2.00	0.95	20%
95-5	24	0.69	0.00	1.39	Insufficient Data
95-6	2.5	1.40	2.80	0.00	Insufficient Data
95-7	20	0.00	0.00	0.00	Insufficient Data
95-8	11	0.14	0.28	0.00	75%
95-9	6	0.93	1.81	0.06	17%
95-10	14	0.63	0.27	0.98	50%
95-11	14	1.95	1.81	2.08	64%
95-12	14	1.59	1.47	1.71	45%
95-13	12	1.06	1.88	0.24	44%
Weighted Average		0.84	0.93	0.77	44%
		2 or 3 Lane Undivided Highway			
Above Average Performance		< 0.94			< 51%
Average Performance		0.94 - 1.06			51% - 57%
Below Average Performance		> 1.06			> 57%
		4 or 5 Lane Undivided Highway			
Above Average Performance		< 0.80			< 42%
Average Performance		0.80 - 1.20			42% - 51%
Below Average Performance		> 1.20			> 51%

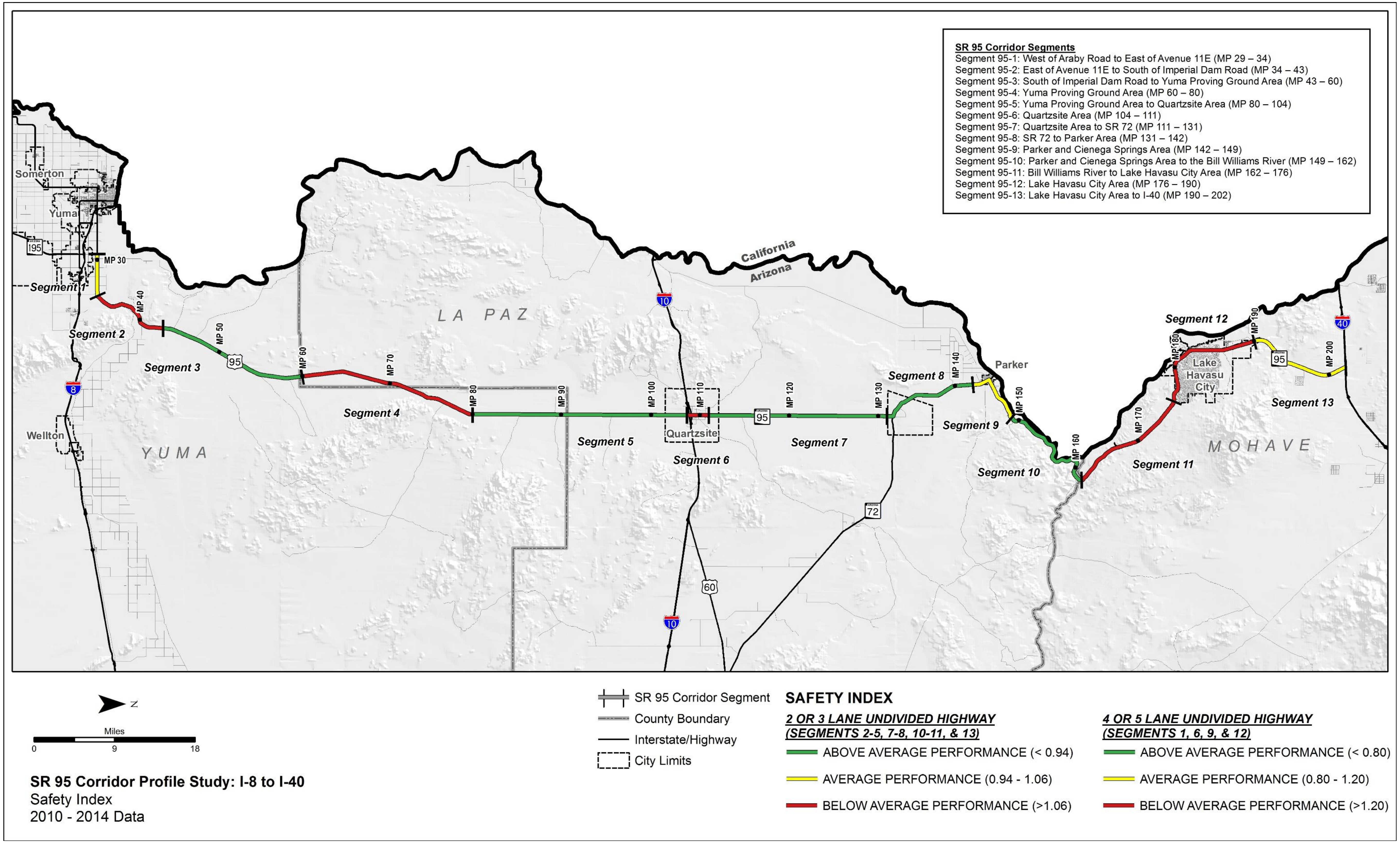


Figure 23 - Safety Index

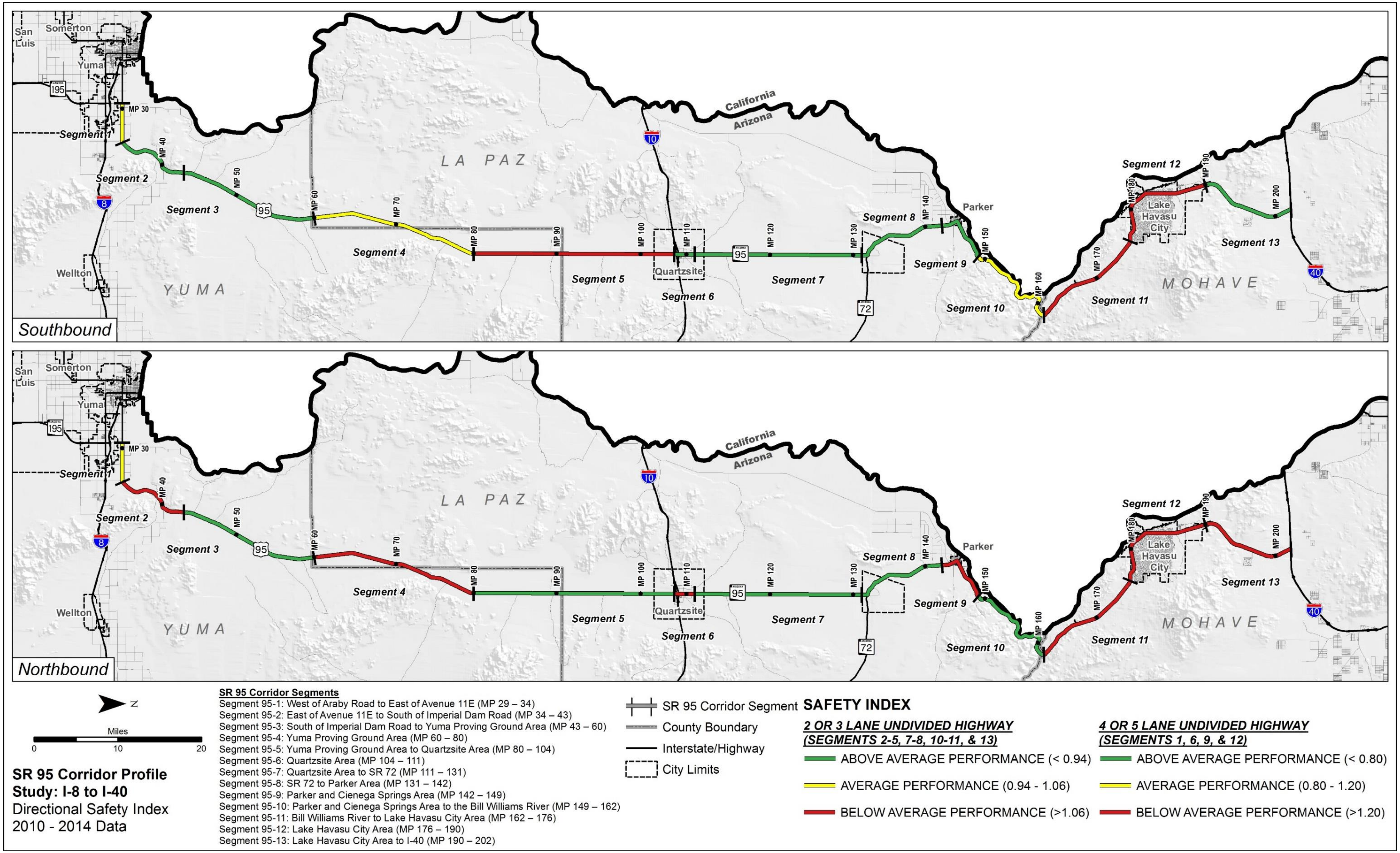


Figure 24 - Directional Safety Index

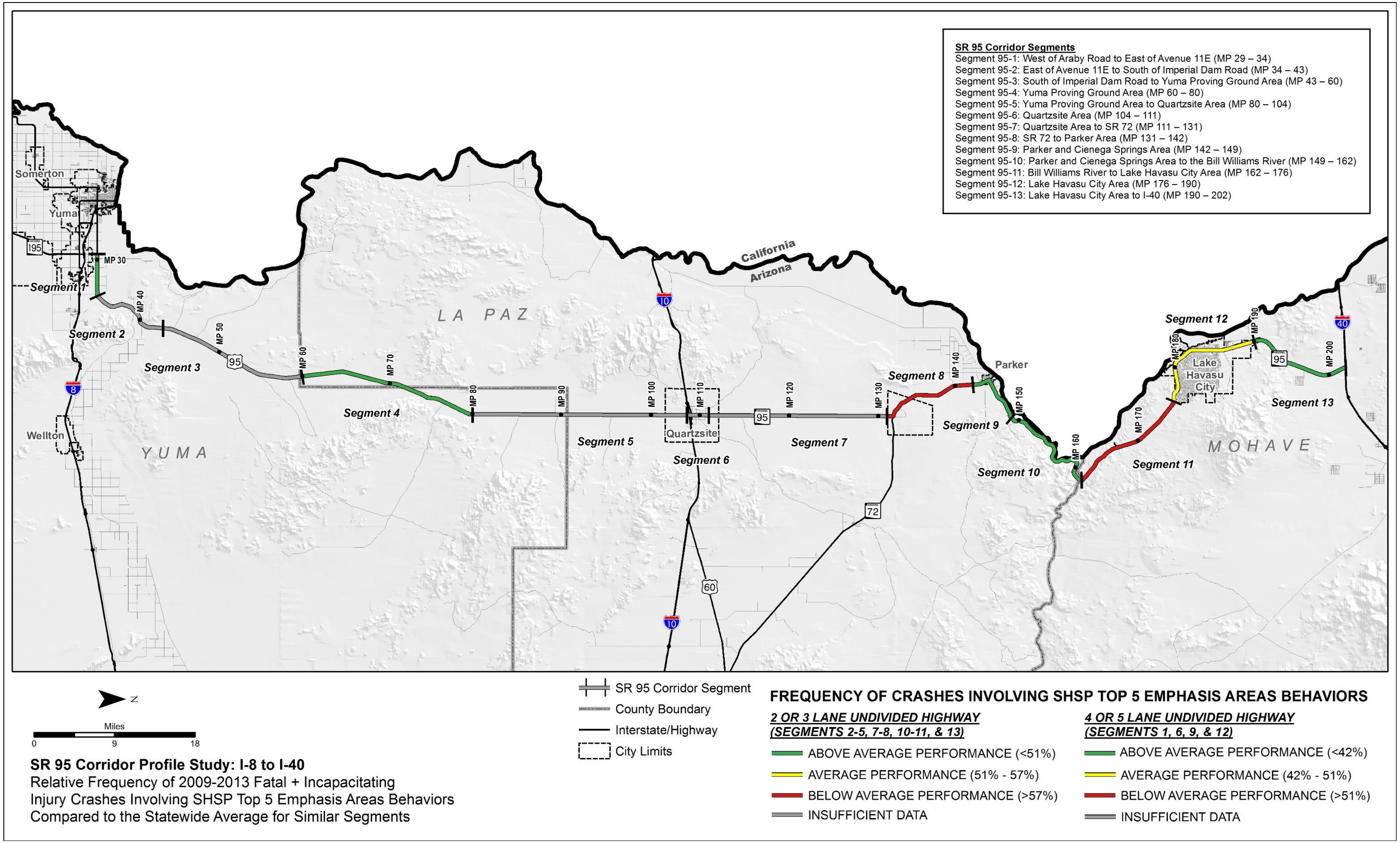


Figure 25 - Frequency of SHSP Top 5 Emphasis Areas

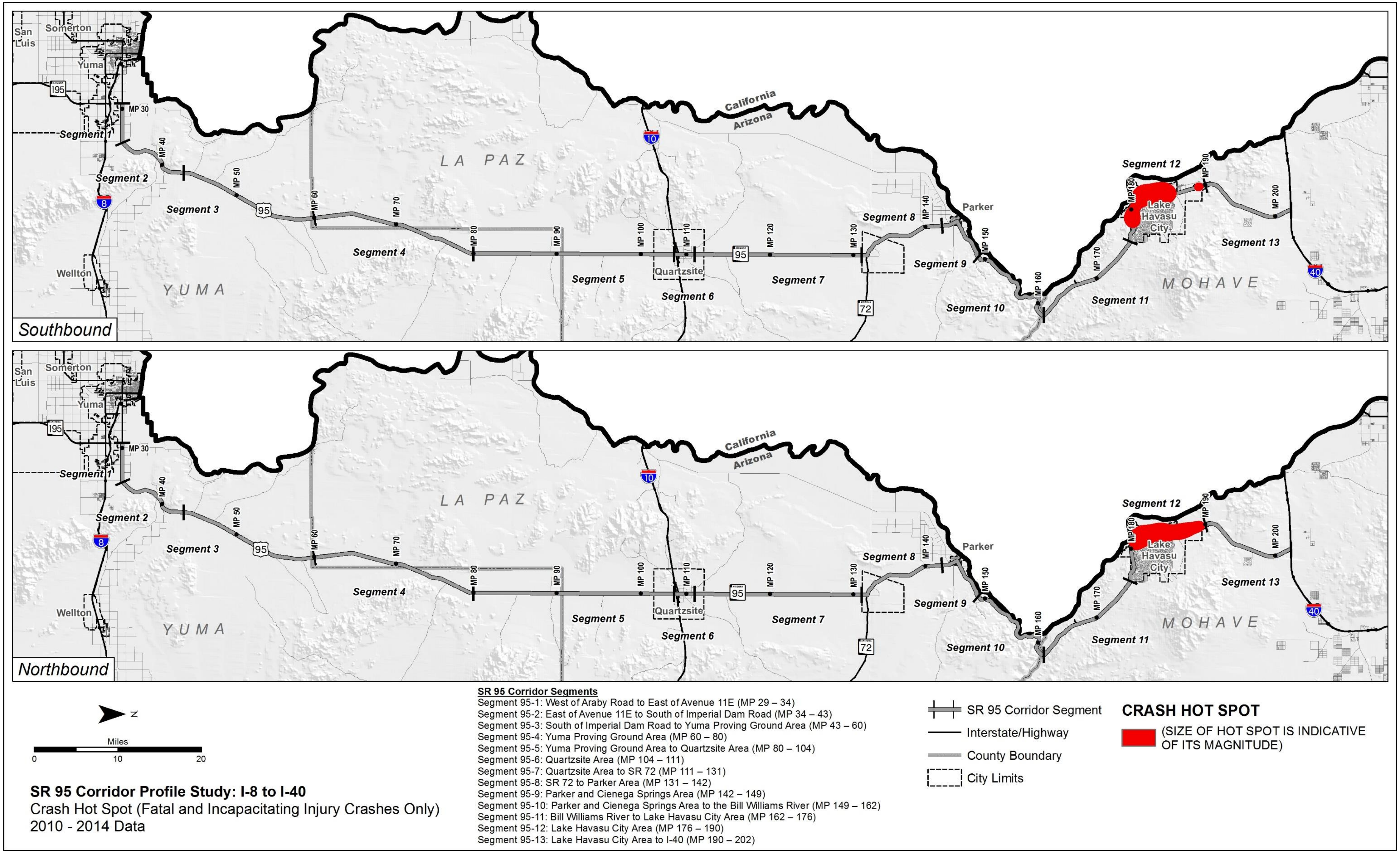


Figure 26 - Crash Hot Spots

3.5 *Freight Performance Area*

The freight performance area consists of a single Freight Index and four secondary measures as illustrated in **Figure 27**. All measures relate to the reliability of truck travel as measured by observed truck travel time speed and delays to truck travel from freeway closures or physical restrictions to truck travel. The Freight Performance Area was developed in collaboration with ADOT's Freight Planner. Detailed information related to the calculations for the Freight Performance Area is included in **Appendix B** of this Working Paper.

Figure 27 - Freight Performance Area Measures

3.5.1 Primary Measure: Freight Index

The Freight Index is a reliability performance measure based on the planning time index for truck travel. The industry standard definition for the Truck Planning Time Index (TPTI) is the ratio of total travel time needed for 95% on-time arrival to free-flow travel time. The TPTI reflects the extra buffer time needed for on-time delivery while accounting for non-recurring delay. Non-recurring delay refers to unexpected or abnormal delay due to closures or restrictions resulting from circumstances such as crashes, inclement weather, and construction activities.

The TPTI can be converted into a speed-based index by recognizing that speed is equal to distance traveled divided by travel time. The inverse relationship between travel time and speed means that the 95th percentile highest travel time corresponds to the 5th percentile lowest speed. The speed-based TPTI is calculated using the following formula:

TPTI = Free-Flow Truck Speed / Observed 5th Percentile Lowest Truck Speed

Observed 5th percentile lowest truck speeds are available in the 2014 American Digital Cartography, Inc. HERE (formerly NAVTEQ) database to which ADOT has access. The free-flow truck speed is assumed to be 65 miles per hour (mph) or the posted speed, whichever is less. This upper limit of 65 mph accounts for governors that trucks often have that restrict truck speeds to no more than 65 mph, even when the speed limit may be higher.

For each corridor segment, the TPTI is calculated for each direction of travel and then averaged to create a bi-directional TPTI. When assessing performance using TPTI, the higher the TPTI value is above 1.0, the more buffer time is needed to ensure on-time delivery.

The Freight Index can be calculated using the following formula to invert the overall TPTI:

Freight Index = 1 / Bi-directional TPTI

This inversion of the TPTI allows the Freight Index to have a scale where the higher the value, the better the performance. This Freight Index scale is based on inverted versions of TPTI scales created previously by ADOT and national research.

The scale for rating the Freight Index is:

Uninterrupted Flow Facilities

- Good: > 0.77
- Fair: 0.67 - 0.77
- Poor: < 0.67

Interrupted Flow Facilities

- Good: > 0.50
- Fair: 0.25 - 0.50
- Poor: < 0.25

3.5.2 Secondary Measures

The Freight Performance Area has four secondary measures:

- Non-Recurring Delay (Directional TPTI)
- Recurring Delay (Directional TTTI)
- Road Closures (Closure Duration)
- Truck Restriction Hot Spots (Vertical Clearance)

Non-Recurring Delay (Directional TPTI)

The performance measure for non-recurring delay is the Directional TPTI. Directional TPTI is calculated as described previously as an interim step in the development of the Freight Index.

For each corridor segment, the TPTI is calculated for each direction of travel. With the TPTI, the higher the TPTI value is above 1.0, the more buffer time is needed to ensure on-time delivery.

The scale for rating the Directional TPTI is the inverse of the Freight Index:

Uninterrupted Flow Facilities

- Good: < 1.3
- Fair: 1.3 - 1.5
- Poor: > 1.5

Interrupted Flow Facilities

- Good: < 2.0
- Fair: 2.0 - 4.0
- Poor: > 4.0

Recurring Delay (Directional TTTI)

The performance measure for recurring delay is the Directional Truck Travel Time Index (TTTI). The industry standard definition for TTTI is the ratio of average peak period travel time to free-flow travel time. The TTTI reflects the extra time spent in traffic during peak times due to recurring delay. Recurring delay refers to expected or normal delay due to roadway capacity constraints or traffic control devices.

Similar to the TPTI, the TTTI can be converted into a speed-based index by recognizing that speed is equal to distance traveled divided by travel time. The speed-based TTTI can be calculated using the following formula:

TTTI = Free-Flow Truck Speed / Observed Average Peak Period Truck Speed

Observed average peak period truck speeds are available in the 2014 American Digital Cartography, Inc. HERE (formerly NAVTEQ) database to which ADOT has access. The free-flow truck speed is assumed to be 65 mph or the posted speed, whichever is less.

For each corridor segment, the TTTI is calculated for each direction of travel. With the TTTI, the higher the TTTI value is above 1.0, the more time is spent in traffic during peak times. TTTI values are generally lower than TPTI values. The Directional TTTI scale is based on TTTI scales created previously by ADOT and national research.

The scale for rating the Directional TTTI is:

Uninterrupted Flow Facilities

- Good: < 1.15
- Fair: 1.15 - 1.33
- Poor: > 1.15

Interrupted Flow Facilities

- Good: < 1.3
- Fair: 1.3 - 2.0
- Poor: > 2.0

Road Closures (Closure Duration)

The performance measure related to road closures is average roadway closure (i.e., full lane closure) duration time. There are three main components to full closures that affect reliability – frequency, duration, and extent. In the freight industry, closure duration is the most important component because trucks want to minimize travel time and delay.

Data on the frequency, duration, and extent of full roadway closures on the ADOT State Highway System is available for 2010-2014 in the Highway Condition Reporting System (HCRS) database that is managed and updated by ADOT.

The average closure duration in a segment – in terms of the average time a milepost is closed per mile per year on a given segment is calculated using the following formula:

*Closure Duration = Sum of Segment (Closure Clearance Time * Closure Extent) / Segment Length*

The segment closure duration time in hours can then be compared to statewide averages for closure duration in hours, with one standard deviation from the average forming the scale break points. The scale for rating closure duration in hours is:

- Good: < 2.21 (2 hours, 13 minutes)
- Fair: 2.21 – 18.04
- Poor: > 18.04 (18 hours)

Truck Restriction Hot Spots (Vertical Clearance)

The performance measure related to truck restrictions is the number of locations, or “hot spots”, where vertical clearance issues restrict truck travel. Sixteen feet is the minimum standard vertical clearance value for interstate bridges.

Locations with lower vertical clearance values than the minimum standard are categorized by the ADOT Intermodal Transportation Department Engineering Permits Section as either locations where ramps exist that allow the restriction to be avoided or locations where ramps do not exist and the restriction cannot be avoided. The locations with vertical clearances below the minimum standard can be mapped to identify their geographic location and whether or not the restricted area can be avoided. Locations with vertical clearance restrictions where ramping around the restriction is not an option are considered “hot spots”.

3.5.3 SR 95 Freight Performance

The Freight Index and Secondary Performance Measures were calculated for the SR 95 corridor using the Freight Performance Area methodology (**Appendix B)**. The calculations were based on data provided by ADOT that includes HERE data from 2014 and closure data from 2010 - 2014. The resulting scores are shown in **Table 7**. The results for the Mobility Index and the Secondary Measures are mapped in **Figure 28 – Figure 31**.

Based on the results of the analysis, the following Freight conditions were observed on SR 95:

- The weighted average of the Freight Index indicates “poor” overall freight mobility conditions for SR 95. A majority of the SR 95 segments show either “poor” or “fair” conditions.

- The weighted average directional TTTI measures indicate "good" conditions with little to no recurring congestion experienced on SR 95 segments.
- The weighted average directional TPTI measures show that the corridor has "poor" travel time reliability in the northbound direction and "fair" travel time reliability in the southbound direction due to non-recurring congestion.
- The TPTI measure indicates that Segments 2, 4, 5, 8, 9, 12, and 13 have the worst performance for reliability.
- Segment 4 northbound has the highest directional TPTI score in the corridor and corresponds to where a border patrol checkpoint exists.
- Segment 1 has "fair" performance in the closure duration performance measure. The overall weighted average shows "good performance for the corridor.
- No vertical clearance restrictions exist along the SR 95 corridor.

Table 7 - Freight Performance Summary

Segment	Segment Length (miles)	Freight Performance Area					
		Freight Index	Directional TTTI		Directional TPTI		Closure Duration (hours/ milepost closed/year/ mile)
			NB	SB	NB	SB	
95-1	5	0.31	1.07	1.06	3.46	2.95	2.28
95-2	9	0.64	1.04	1.00	1.96	1.17	0.61
95-3	17	0.76	1.30	1.03	1.30	1.34	0.16
95-4	20	0.13	1.27	1.06	13.64	1.46	0.23
95-5	24	0.74	1.01	1.06	1.11	1.57	0.11
95-6	2.5	0.35	1.06	1.46	1.97	3.76	1.21
95-7	20	0.70	1.05	1.04	1.40	1.44	0.44
95-8	11	0.53	1.07	1.06	2.24	1.50	0.50
95-9	6	0.24	1.09	1.05	4.89	3.38	0.90
95-10	14	0.78	1.01	1.04	1.33	1.24	0.85
95-11	14	0.73	1.00	1.03	1.29	1.44	1.27
95-12	14	0.22	1.34	1.22	5.39	3.80	1.31
95-13	12	0.37	1.09	1.07	2.36	3.06	0.86
Weighted Average		0.53	1.08	1.03	3.35	1.82	0.62
Uninterrupted							
Good		> 0.77	< 1.15		< 1.3		< 2.21
Fair		0.67 - 0.77	1.15 - 1.33		1.3 - 1.5		2.21-18.04
Poor		< 0.67	> 1.33		> 1.5		> 18.04
Interrupted							
Good		> 0.50	< 1.3		< 2.0		< 2.21
Fair		0.25 - 0.50	1.3 - 2.0		2.0 - 4.0		2.21-18.04
Poor		< 0.25	> 2.0		> 4.0		> 18.04

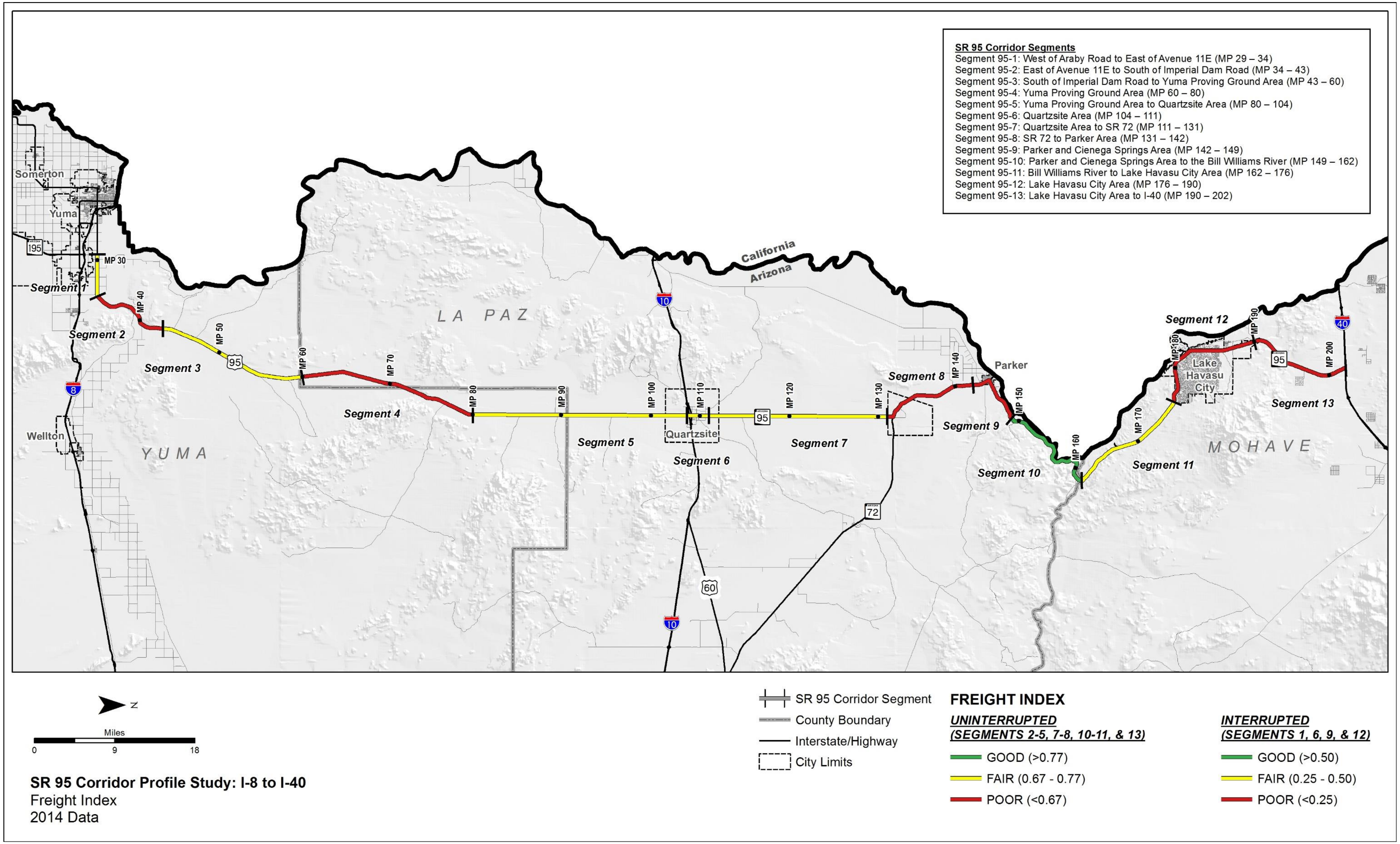


Figure 28 - Freight Index

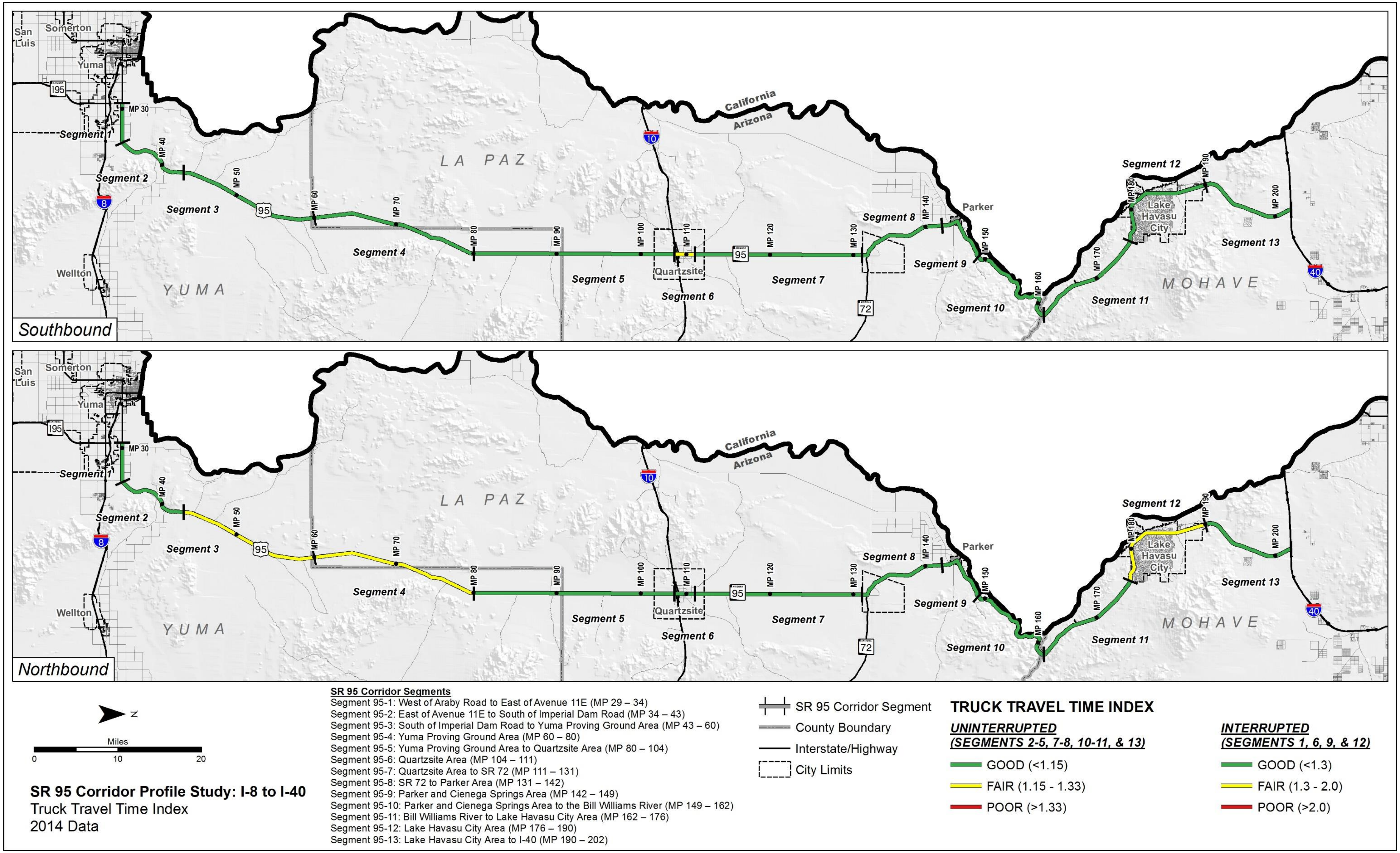


Figure 29 - Truck Travel Time Index

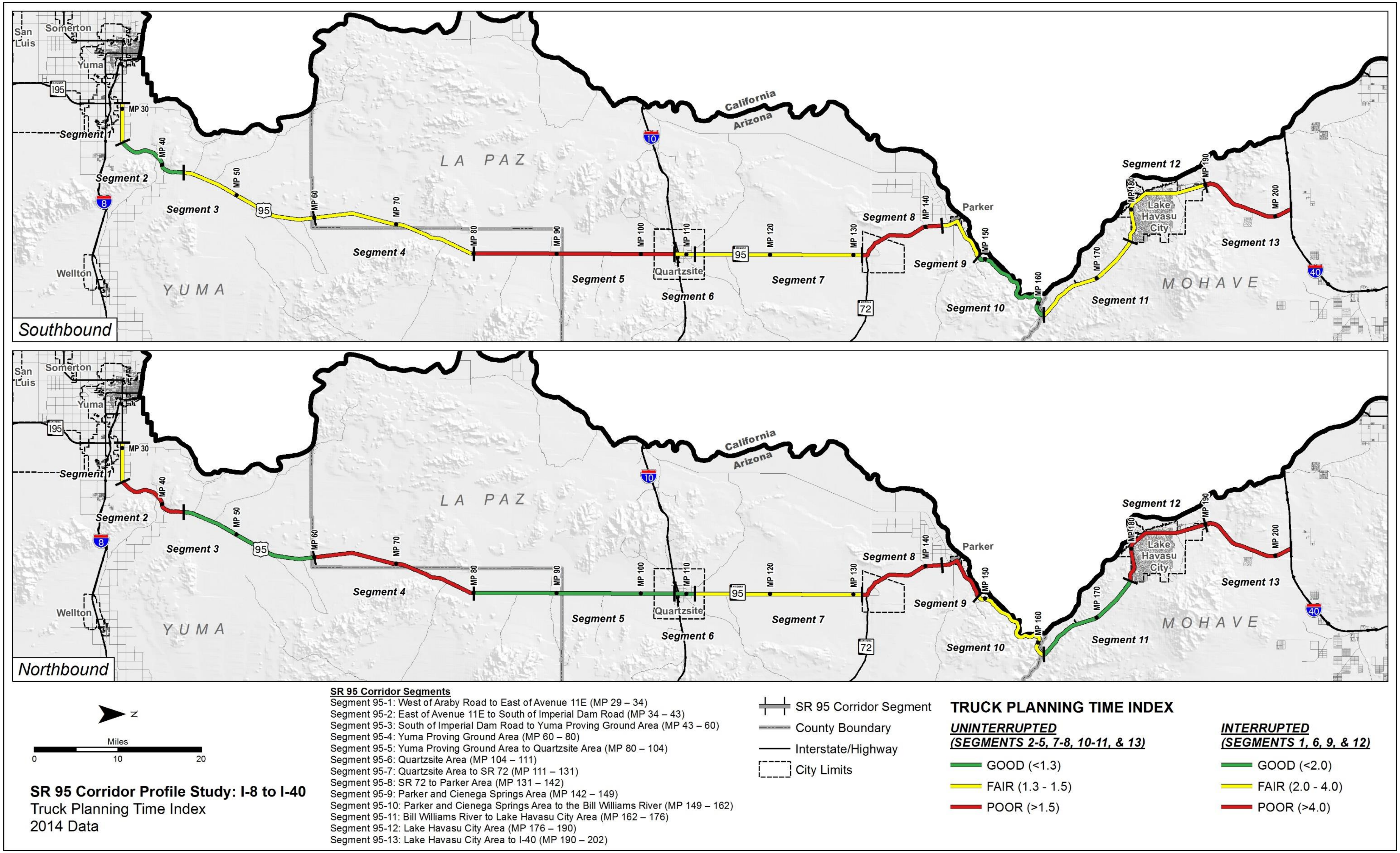
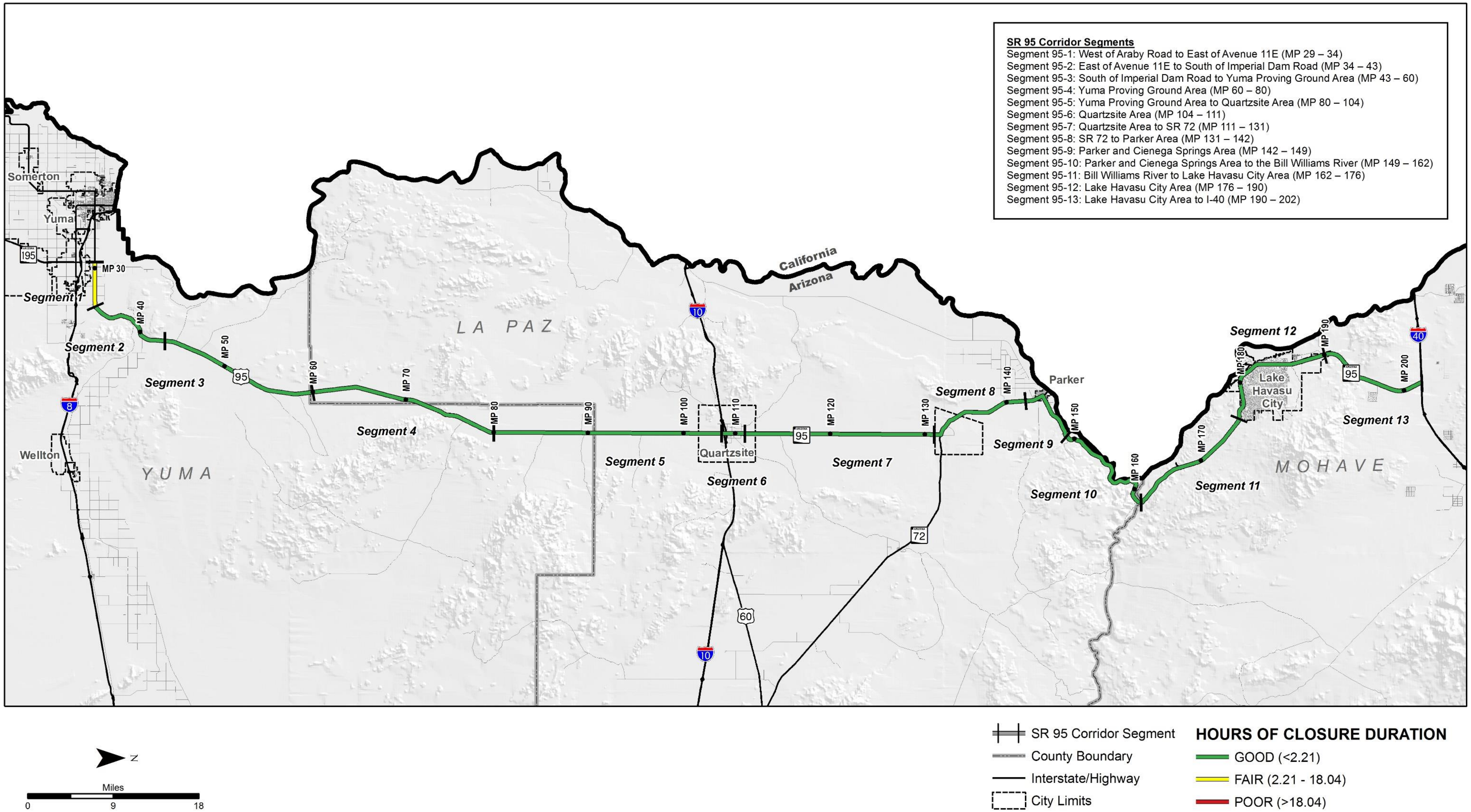


Figure 30 - Truck Planning Time Index



SR 95 Corridor Profile Study: I-8 to I-40
2010 - 2014 Average Hours Per Year A Given Milepost Is Closed Per Segment Mile

Figure 31 - Closures in Hours per Mile per Year

4 Corridor Performance Summary

The performance framework presented in the prior chapter includes a process for assessing the baseline (current) health of the SR 95 corridor and its component segments in terms of performance in the areas of Pavement, Bridge, Mobility, Safety, and Freight. This chapter presents a summary of the overall baseline performance of the corridor and each performance area on a segment-by-segment basis.

Overall corridor performance in terms of the primary performance measures or performance indices was quantified using a weighted (by segment length) average of each primary performance measure. **Table 8** provides a performance index summary table for each segment for each of the five performance areas and the overall weighted performance rating for all corridor segments combined. The scaling for each Performance Index was used to rate the weighted average for each performance area. The overall corridor weighted average performance for each performance index is as follows:

- The weighted average of the Pavement Index indicates "good" overall pavement conditions for the SR 95 corridor.
- The weighted average of the Bridge Index indicates "fair" overall conditions for SR 95 bridges.
- The weighted average of the Mobility Index indicates "good" overall mobility conditions for SR 95.
- The weighted average of the Safety Index indicates "above average" (good) overall safety conditions for SR 95.
- The weighted average of the Freight Index indicates "poor" freight reliability conditions for SR 95.

Overall corridor performance in terms of the secondary performance measures was quantified where feasible using a weighted (by segment length) average of each secondary measure. Weighted averages cannot be calculated for the hot spot secondary measures so they were excluded from the overall corridor performance calculations but are included in the maps of the performance measures for use in more detailed analysis to be conducted later in the study.

The percentage of the SR 95 corridor, based on segment length, that rates either "Good/Above Average Performance", "Fair/Average Performance", or "Poor/Below Average Performance" in each primary index is illustrated in **Figure 32.** On SR 95, freight is the lowest performing area with 43% of the corridor in "Poor" condition as it relates to the primary index. Pavement and Mobility are the highest performing areas along SR 95 with at least 85% and 92% of the corridor in "good" condition as it relates to the primary index.

Figure 33 provides a performance index summary map for each segment for each of the five performance areas and the overall weighted performance rating for all corridor segments combined. **Figure 34** graphically summarizes overall corridor performance for both the primary and secondary measures with a text description of each of the primary and secondary measures.

Figure 32 - Performance Index Summary

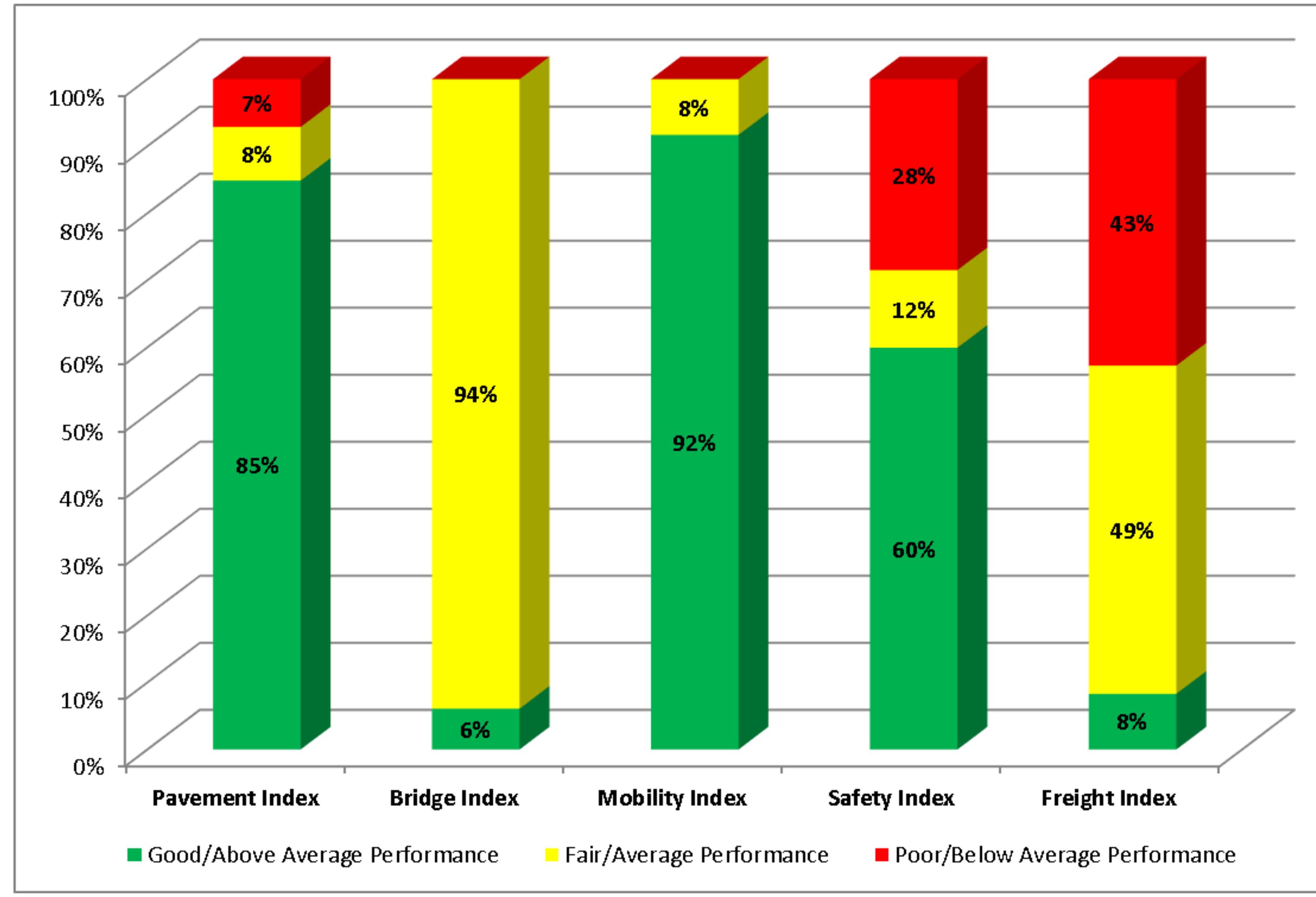
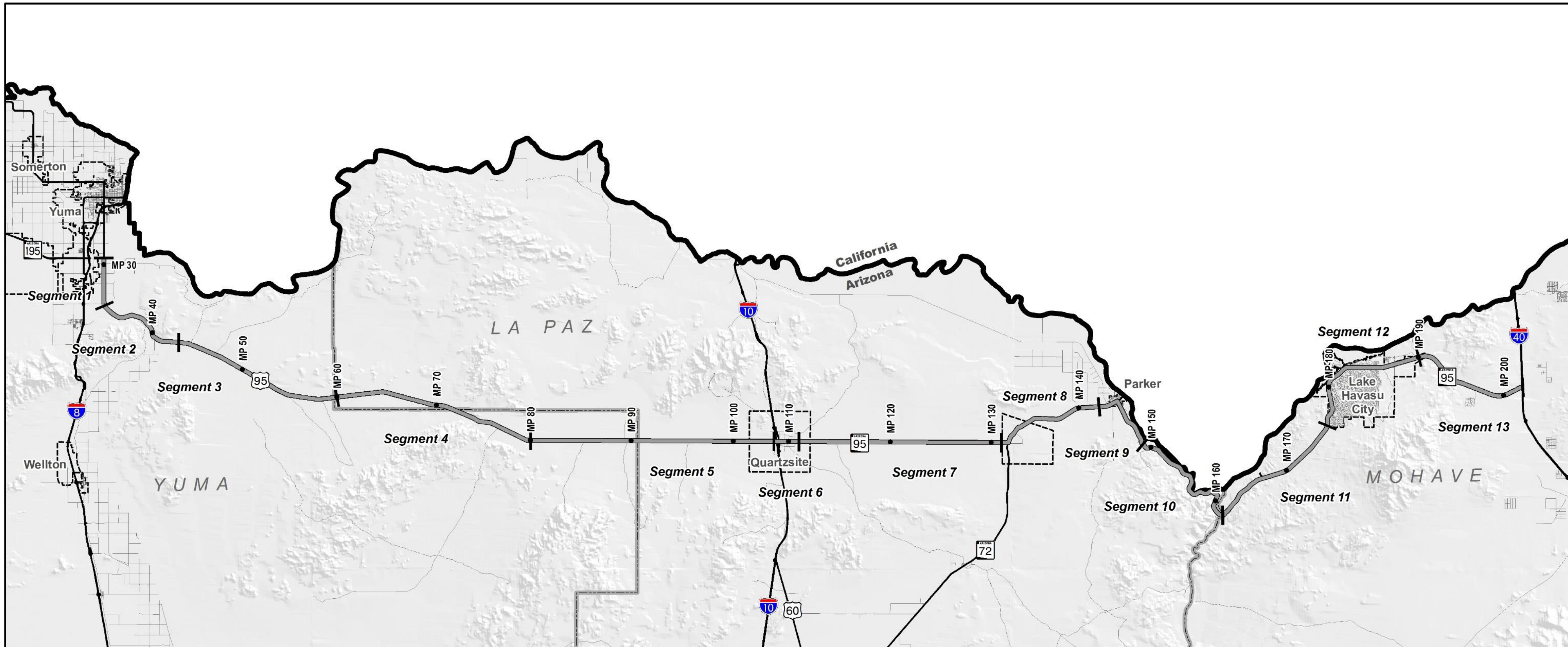


Table 8 - Performance Summary

Segment	Segment Length (miles)	Pavement Performance Area: Pavement Index	Directional PSR NB	Directional PSR SB	% Area Failure	Bridge Performance Area: Bridge Index	Bridge Sufficiency	% Bridges Functionally Obsolete	Bridge Rating	Mobility Performance Area: Mobility Index	Future Daily V/C	Existing Peak Hour V/C NB	Existing Peak Hour V/C SB	Closure Extent (instances/ milepost/year/mile) NB	Closure Extent SB	Directional TTI (all vehicles) NB	Directional TTI SB	Directional PTI (all vehicles) NB	Directional PTI SB	% Non-Single Occupancy Vehicle (SOV) Opportunities	% Bicycle Accommodation
95-1	5	3.54	3.64		0.0%	6.00	80.87	0.0%	6	0.43	0.51	0.33	0.30	0.32	0.28	1.07	1.10	2.99	3.71	18.6%	62%
95-2	9	3.82	3.78		0.0%	6.00	78.12	8.5%	6	0.31	0.37	0.22	0.22	0.18	0.13	1.03	1.03	2.18	1.30	19.8%	56%
95-3	17	3.61	3.51		35.3%	5.00	68.22	0.0%	5	0.10	0.12	0.10	0.10	0.02	0.06	1.03	1.03	1.27	1.28	19.8%	8%
95-4	20	4.41	4.28		0.0%	No Bridges				0.12	0.14	0.08	0.07	0.05	0.01	1.18	1.06	5.36	1.42	5.0%	0%
95-5	24	4.14	4.12		0.0%	No Bridges				0.12	0.14	0.08	0.08	0.05	0.04	1.02	1.08	1.17	1.56	23.0%	2%
95-6	2.5	3.27	3.23		33.3%	6.00	76.00	0.0%	6	0.48	0.63	0.31	0.35	0.24	0.08	1.06	1.39	4.79	5.98	24.6%	87%
95-7	20	3.68	3.76		5.0%	6.00	79.00	0.0%	6	0.16	0.22	0.09	0.10	0.14	0.10	1.06	1.04	1.28	1.37	14.6%	0%
95-8	11	3.39	3.27		9.1%	5.00	67.00	0.0%	5	0.32	0.43	0.17	0.17	0.13	0.05	1.08	1.04	1.90	1.45	9.1%	25%
95-9	6	3.59	3.84		14.3%	6.76	80.86	0.0%	6	0.57	0.62	0.45	0.42	0.43	0.37	1.08	1.06	5.41	3.58	11.4%	61%
95-10	14	3.62	3.59		0.0%	6.25	78.25	0.0%	6	0.21	0.23	0.18	0.10	0.21	0.17	1.04	1.04	1.38	1.33	2.2%	2%
95-11	14	4.13	4.13		0.0%	No Bridges				0.16	0.18	0.13	0.09	0.33	0.27	1.04	1.01	1.30	1.38	8.3%	0%
95-12	14	3.77	3.51	4.15	14.3%	5.46	76.82	20.2%	5	0.78	1.02	0.53	0.52	0.43	0.43	1.32	1.23	4.98	3.89	18.1%	9%
95-13	12	2.77	3.77		24.7%	No Bridges				0.22	0.26	0.16	0.15	0.27	0.32	1.05	1.08	3.33	3.93	14.3%	71%
Weighted Average		3.65	3.80	3.86	8.7%	5.72	75.44	3.7%	6	0.24	0.30	0.17	0.16	0.17	0.15	1.05	1.03	2.46	1.93	13.5%	17%

Segment	Safety Performance Area: Safety Index	NB Directional Safety Index	SB Directional Safety Index	% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	Freight Performance Area: Freight Index	Directional TTTI NB	Directional TTTI SB	Directional TPTI NB	Directional TPTI SB	Closure Duration (hours/ milepost closed/year/ mile)
95-1	1.13	1.13	1.13	17%	0.31	1.07	1.06	3.46	2.95	2.28
95-2	1.29	2.43	0.16	Insufficient Data	0.64	1.04	1.00	1.96	1.17	0.61
95-3	0.06	0.11	0.00	Insufficient Data	0.76	1.30	1.03	1.30	1.34	0.16
95-4	1.48	2.00	0.95	20%	0.13	1.27	1.06	13.64	1.46	0.23
95-5	0.69	0.00	1.39	Insufficient Data	0.74	1.01	1.06	1.11	1.57	0.11
95-6	1.40	2.80	0.00	Insufficient Data	0.35	1.06	1.46	1.97	3.76	1.21
95-7	0.00	0.00	0.00	Insufficient Data	0.70	1.05	1.04	1.40	1.44	0.44
95-8	0.14	0.28	0.00	75%	0.53	1.07	1.06	2.24	1.50	0.50
95-9	0.93	1.81	0.06	17%	0.24	1.09	1.05	4.89	3.38	0.90
95-10	0.63	0.27	0.98	50%	0.78	1.01	1.04	1.33	1.24	0.85
95-11	1.95	1.81	2.08	64%	0.73	1.00	1.03	1.29	1.44	1.27
95-12	1.59	1.47	1.71	45%	0.22	1.34	1.22	5.39	3.80	1.31
95-13	1.06	1.88	0.24	44%	0.37	1.09	1.07	2.36	3.06	0.86
Weighted Average	0.84	0.93	0.77	44%	0.53	1.08	1.03	3.35	1.82	0.62

Performance Level	Pavement Index	Directional PSR	% Area Failure	Bridge Index	Bridge Sufficiency	% Bridges Functionally Obsolete	Bridge Rating	Mobility Index / Future Daily V/C / Existing Peak Hour V/C	Closure Extent	Directional TTI	Directional PTI	% Non-SOV Opportunities	% Bicycle Accommodation	Safety Index / Directional Safety Index	% of Fatal + Incapacitating Injury Crashes	Freight Index	Directional TTTI	Directional TPTI	Closure Duration
								Urban		Uninterrupted				2 or 3 Lane Undivided Highway			Uninterrupted		
Good/Above Average Performance	> 3.50	> 3.50	< 5%	> 6.5	> 80	< 12%	> 6	< 0.71	< 0.38	< 1.15	< 1.3	> 17%	> 90%	< 0.94	< 51%	> 0.77	< 1.15	< 1.3	< 2.21
Fair/Average Performance	2.90 - 3.50	2.90 - 3.50	5% - 20%	5.0 - 6.5	50 - 80	12% - 40%	5 - 6	0.71 - 0.89	0.38 - 1.46	1.15 - 1.33	1.3 - 1.5	11% - 17%	60% - 90%	0.94 - 1.06	51% - 57%	0.67 - 0.77	1.15 - 1.33	1.3 - 1.5	2.21-18.04
Poor/Below Average Performance	< 2.90	< 2.90	> 20%	< 5.0	< 50	> 40%	< 5	> 0.89	> 1.46	> 1.33	> 1.5	< 11%	< 60%	> 1.06	> 57%	< 0.67	> 1.33	> 1.5	> 18.04
								Rural		Interrupted				4 or 5 Lane Undivided Highway			Interrupted		
Good/Above Average Performance	> 3.50	> 3.50	< 5%	> 6.5	> 80	< 12%	> 6	< 0.56	< 0.38	< 1.3	< 2.0	> 17%	> 90%	< 0.80	< 42%	> 0.50	< 1.3	< 2.0	< 2.21
Fair/Average Performance	2.90 - 3.50	2.90 - 3.50	5% - 20%	5.0 - 6.5	50 - 80	12% - 40%	5 - 6	0.56 - 0.76	0.38 - 1.46	> 1.3 & < 2.0	> 2.0 & < 4.0	11% - 17%	60% - 90%	0.80 - 1.20	42% - 51%	0.25 - 0.50	1.3 - 2.0	2.0 - 4.0	2.21-18.04
Poor/Below Average Performance	< 2.90	< 2.90	> 20%	< 5.0	< 50	> 40%	< 5	> 0.76	> 1.46	> 2.0	> 4.0	< 11%	< 60%	> 1.20	> 51%	< 0.25	> 2.0	> 4.0	> 18.04



	95-1	95-2	95-3	95-4	95-5	95-6	95-7	95-8	95-9	95-10	95-11	95-12	95-13	Weighted Average
Pavement	3.54	3.82	3.61	4.41	4.14	3.27	3.68	3.39	3.59	3.62	4.13	3.77	2.77	3.65
Bridge	6.00	6.00	5.00	No Bridges	No Bridges	6.00	6.00	5.00	6.76	6.25	No Bridges	5.46	No Bridges	5.72
Mobility	0.43	0.31	0.10	0.12	0.12	0.48	0.16	0.32	0.57	0.21	0.16	0.78	0.22	0.24
Safety	1.13	1.29	0.06	1.48	0.69	1.40	0.00	0.14	0.93	0.63	1.95	1.59	1.06	0.84
Freight	0.31	0.64	0.76	0.13	0.74	0.35	0.70	0.53	0.24	0.78	0.73	0.22	0.37	0.53

N

Miles

0 9 18

SR 95 Corridor Profile Study: I-8 to I-40

Primary Performance Index Summary

Performance Index Scale

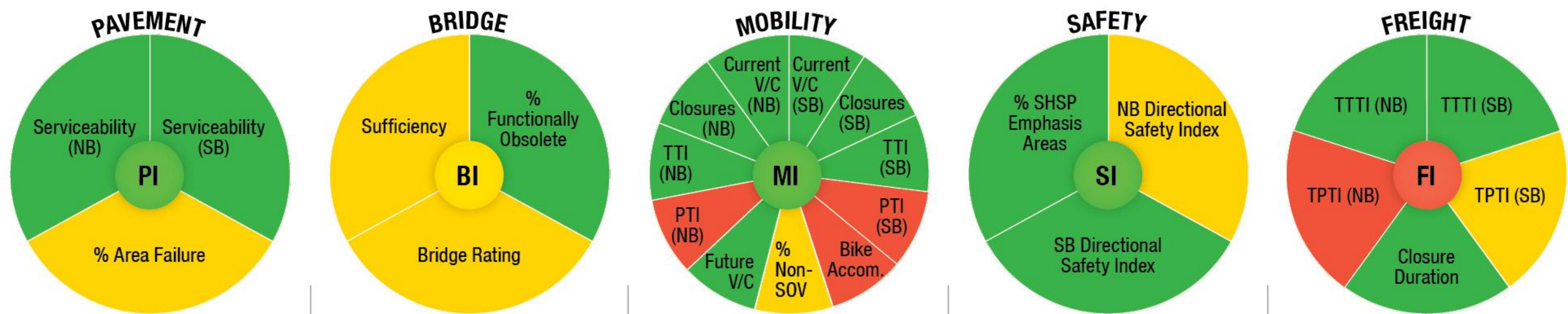
- Good/Above Average Performance
- Fair/Average Performance
- Poor/Below Average Performance

- SR 95 Corridor Segment
- County Boundary
- Interstate/Highway
- City Limits

Figure 33 - Summary of Overall Corridor Performance for Primary Measures

Figure 34 - Summary of Overall Corridor Performance for Primary and Secondary Measure

SR 95 Corridor Performance Study (all performance measures are weighted averages for all segments of the corridor) GOOD FAIR POOR



Pavement Index (PI): based on two pavement condition ratings from the ADOT Pavement Database. The two ratings are the International Roughness Index (IRI) and the Cracking Rating. The calculation of the Pavement Index uses a combination of these two ratings.

- **Directional Pavement Serviceability** - the weighted average (based on number of lanes) rating which measures the condition of the pavement in each direction of travel.
- **% Pavement Failure** - the percentage of pavement area that is rated above the failure thresholds for IRI or Cracking, as established by ADOT Materials Group (IRI > 105 or Cracking > 15)

Bridge Index (BI): based on four bridge condition ratings from the ADOT Bridge Database. The four ratings are the Deck Rating, Substructure Rating, Superstructure Rating, and Structural Evaluation Rating.

- **Sufficiency** - indicative of bridge sufficiency to remain in service. The factors that contribute to the Sufficiency Rating include structural adequacy and safety, serviceability and functional obsolescence, and essentiality for public use.
- **% Functionally Obsolete** - indicative of the percentage of deck area on bridges that is no longer functionally adequate for its current use, such as a lack of shoulders or the inability to handle current traffic volumes. Functionally Obsolete does not directly relate to the structural adequacy.
- **Bridge Rating** - identifies the lowest bridge rating on each segment.

Mobility Index (MI): an average of the current volume-to-capacity (V/C) ratio and the projected 2035 V/C ratio.

- **Current V/C** - the existing peak hour V/C ratio in both directions of the corridor. This measure provides an understanding of the directional operating characteristics of the corridor during the existing peak hour from a mobility and congestion standpoint.
- **Future V/C** - a measurement of the future 2035 V/C ratio that identifies how the corridor will operate in the future from a mobility and congestion standpoint.
- **Directional Closures** - the average number of times a given location in the corridor was closed per mile in a specific direction of travel per year.
- **Travel Time Index (TTI)** - the ratio of the average peak period travel time to the free-flow travel time. The TTI represents recurring delay along the corridor.
- **Directional Planning Time Index (PTI)** - the ratio of total travel time needed for 95 percent on-time arrival to free-flow travel time. The PTI represents non-recurring delay along the corridor.
- **% Non-single Occupancy Vehicle Trips (Non-SOV)** - represents the percentage of trips that are taken by vehicles carrying more than one occupant.
- **Bicycle Accommodation** - represents the percentage of roadway that is accommodating for bicycle travel.

Safety Index (SI): combines the bi-directional frequency and rate of fatal and incapacitating injury crashes, compared to crash occurrences on similar roadways in Arizona.

- **% SHSP Emphasis Area** - the percentage of fatal and incapacitating crashes that involve at least one of the five Strategic Highway Safety Plan (SHSP) Emphasis Areas.
- **% Truck Crashes** - the percentage of fatal and incapacitating crashes that involve a truck.

Freight Index (FI): a reliability performance measure based on the bi-directional planning time index for truck travel.

- **Directional Truck Planning Time Index (TPTI)** - the ratio of total travel time (for trucks only) needed for 95 percent on-time arrival to free-flow travel time. The TTPI represents non-recurring delay along the corridor.
- **Directional Truck Travel Time Index (TTTI)** - the ratio of the average peak period travel time (for trucks only) to the free-flow travel time. The TTTI represents recurring delay that occurs along the corridor.
- **Closure Duration** - the average time a given location in the corridor was closed per mile per year.

5 Agency Discussions

Meetings were held with the following agencies to review the performance framework, performance measures, and performance outcome.

ADOT Kingman District/WACOG/LHMPO: September 25, 2015. This meeting was attended by Heidi Yaqub (ADOT MPD I-40 Project Manager), Asad Karim (ADOT MPD SR 95 Project Manager), Todd Steinberger (ADOT Kingman District), Kara Lavertue (ADOT Kingman District), Chris Olson (ADOT Kingman District), Gary Parsons (Lake Havasu City for LHMPO), Felicia Mondragon (WACOG), Brent Crowther (Kimley-Horn), Michael Grandy (Kimley-Horn), Jason Freitas (Kimley-Horn).

- **ADOT Yuma District/YMPO:** September 28, 2015. This meeting was attended by Asad Karim (ADOT MPD Project Manager), Tazeen Dewan (ADOT MPD Project Manager), Michael Jones (ADOT Yuma District), Isabell Garcia (ADOT Yuma District), Paul Patane (ADOT Yuma District), Charlene FitzGerald (YMPO), Brent Crowther (Kimley-Horn), Jason Freitas (Kimley-Horn), Joy Melita (PB), Scott Pitera (PB).

Input received during these meetings is summarized below by Performance Area.

Pavement Performance Area

- The primary and secondary performance measures, overall, are consistent with ADOT's field experience.
- It was noted that pavement hot spots within MP 46–54 (Segment 3) should have been addressed with a recent chip seal project.
- A micro/slurry seal was performed at MP 104–111 (Segment 6) within the Quartzsite city limits. Some cracking was observed but wasn't thought to be considered area of failure.
- Funding was requested for a chip-sealing at MP 116-132 (Segment 7).
- From the SR 72 junction to MP 142 (Segment 8), a chip seal project was performed 3-4 years ago.
- It was noted that a section within Lake Havasu City (Segment 12) was widened in the early 2000's
- In the southbound direction, MP 180/182 south of Mulberry, a significant dip is forming in the pavement.
- It was confirmed that the poor pavement performance for segment 13 was not reflected recent installation of NB passing lanes.

Bridge Performance Area

- The district agrees that due to the low number of bridges along SR 95, with the exception of a couple of bridges, they have not identified any major problems. However, additional bridges are desired at major washes. Low water crossings during major storm events result in closures of the corridor that impact mobility, freight movements and create maintenance issues during storms.
- The Falls Springs Wash Bridge in Lake Havasu City (Segment 12) has been observed to be structurally fit. However, uneven settlements of the abutments are causing the pavement to be rough. Reduced speed limit signs have been installed for both directions of traffic. The bridge has a recent deck rating of 5.
- The district described the McCulloch Boulevard Overpass as being functionally obsolete. This is consistent with ADOT's bridge report which classifies the bridge as being functionally obsolete. However, the bridge component ratings do not meet the criteria to be a bridge hot spot.
- Funding for a new bridge has been requested between MP 60-80 (Segment 4) as there is a major wash that exists.

Mobility Performance Area

- Seasonal traffic is a major concern by the districts. They noted that peak traffic volumes, which occur during winter months, may have not be completely reflected in the Mobility Performance Area. The winter months and particularly February and March experience significant increases in traffic volumes with the arrival of seasonal residents and special events (RV Show and Gem Show) which attract high volumes of recreation vehicles traveling along SR 95.
- The districts find that the Vehicle Planning Time Index is consistent with their observations regarding congestion. Within Lake Havasu City (Segment 12), the congestion can be associated with traffic signals. It was noted that there is not a central traffic signal system which could help to coordinate the traffic signals
- Congestion along segment 13 can be attributed to recreational vehicles pulling on/off to park overnight on the adjacent BLM land. It was noted that a fencing project in coordination with BLM was performed in 2014 to limit access.
- Southbound congestion along segment 13 may be caused by slow vehicles and the removal of passing opportunities with the recent passing/climbing lane installed in the northbound direction.
- The districts agree with the % Bicycle Accommodation performance measure, as shoulder widths are not to roadway design standards and/or in a condition to accommodate bicycle travel. The districts noted that there is a large bicycle community that is increasing, especially in the northern section of SR 95 around Lake Havasu City that are expressing concern.
- The shared use path in Lake Havasu City runs along one side of SR 95 and crosses it approximately 4 times which may not be ideal for pedestrians or casual cyclists.
- Closures have been recognized as a mobility issues along SR 95 with the large number of low water crossings.

Safety Performance Area

- Animal related crashes are commonly occurring along SR 95, especially within the Yuma district. An RSA has been recently requested for the areas around MP 34-55 (segment 2-3). The district estimated approximately 60 crashes involving animals. However, many of the crashes did not involve fatalities or incapacitating injuries. It was noted that the Corridor Profile Study process emphasizes locations that have demonstrated a pattern of incapacitating injury or fatal crashes. The direction to focus on injury and fatal crashes only was provided by the ADOT Traffic Safety Section. This is consistent with MAP-21 guidance. It was noted that while animal collisions are a significant issue, they have not led to incapacitating or fatal crashes on the SR 95 corridor.

- The northern portion of segment 12 within Lake Havasu City doesn't have access control measures as the rest of the segment. Thus, it is expected that crashes will be more concentrated in that area, especially related to left-turns.
- During peak periods (February-March), increased volumes of recreational vehicles traveling at speeds lower than the posted speed limit create safety issues.
- Shoulder widths that are not to ADOT standards are a safety concern for the districts.

Freight Performance Area

- SR 95 continues to experience an increase in trucks with oversized loads. This is due to the restriction in place on other corridors.
- Inadequate shoulder widths don't allow opposing vehicles of trucks with oversized loads to pull merge outside the lane without driving on non-shoulder conditions.
- The district noted that low water crossings impact freight movements during closures due to storms.

Appendix A – Performance Methodology Refinements

Round 1 of the corridor profile studies developed a methodology for assessing the performance of three corridors (I-17, I-19, and I-40 West) in five performance areas (pavement, bridge, mobility, safety, and freight). Round 2 involves three new corridors (I-8, I-40 East, and SR 95), with one of those – SR 95 – being a non-interstate facility with some interrupted flow segments. The characteristics of these new corridors – particularly SR 95 – along with lessons learned from subsequent tasks of Round 1, have resulted in the following refinements to the performance methodology that will be applied to Round 2:

A. Pavement

Threshold modifications for non-interstate facilities – ADOT has different pavement performance thresholds for non-interstate facilities than for interstate facilities because non-interstate facilities are held to a lower standard than interstate facilities. The following thresholds apply to Round 2:

Table A-1: Pavement Performance Thresholds for Interstates

Performance Level	IRI (PSR)	Cracking (PDI)
Good	<75 (>3.75)	<7 (>3.75)
Fair	75 - 117 (3.20 - 3.75)	7 - 12 (3.22 - 3.75)
Poor	>117 (<3.20)	>12 (<3.22)

Table A-2: Pavement Performance Thresholds for Non-Interstates

Performance Level	IRI (PSR)	Cracking (PDI)
Good	<94 (>3.5)	<9 (>3.5)
Fair	94 - 142 (2.9 - 3.5)	9 - 15 (2.9 - 3.5)
Poor	>142 (<2.9)	>15 (<2.9)

B. Bridge

Expansion of hot spot definition – The bridge hot spot definition has been expanded to include not only bridges with a rating of 4 but also bridges with multiple ratings of 5.

C. Mobility

- Future volumes – Due to questionable future volume projections from the 2014 Statewide Travel Demand Model (AZTDM), the 2013 AZTDM model used for Round 1 will also be used for Round 2.
- Capacity calculations – The Florida Department of Transportation (FDOT) roadway capacity assumptions applied in Round 1 have been replaced by the alternate roadway capacity estimation methodology known as the Highway Economic Requirements System (HERS) that the Federal Highway Administration (FHWA) recently developed. HERS is based on the 2010 Highway Capacity Manual (HCM) and provides more opportunities for local condition factor adjustments than the FDOT methodology. More information on the HERS methodology is provided in the Mobility performance area methodology write-up.
- TTI/PTI on Interrupted Flow facilities – Different performance thresholds have been developed for travel time index (TTI) and planning time index (PTI) on interrupted flow facilities than on uninterrupted flow facilities because interrupted flow facilities have lower free-flow values. The following thresholds apply to Round 2:

Table C-1: TTI and PTI Performance Thresholds for Uninterrupted Flow Facilities

Performance Level	TTI	PTI
Good	<1.15	<1.3
Fair	1.15 - 1.33	1.3 - 1.5
Poor	>1.33	>1.5

Table C-2: TTI and PTI Performance Thresholds for Interrupted Flow Facilities

Performance Level	TTI	PTI
Good	<1.3	<2.0
Fair	1.3 – 2.0	2.0 – 4.0
Poor	>2.0	>4.0

- Bicycle accommodation along facilities – A new secondary performance measure has been developed that evaluates the usability of shoulders by bicyclists based on shoulder widths, shoulder surface type, roadway speed limit, and roadway annual average daily traffic (AADT) volumes. More information on the methodology for bicycle accommodation along facilities is provided in the Mobility performance area methodology write-up.

D. Safety

- Similar operating environments – Round 1 introduced the concept of evaluating safety performance by comparing a given segment to other segments statewide with similar characteristics, known as similar operating environments (SOE); in Round 1 the SOEs applied were tailored to each specific corridor; in Round 2 the SOEs have been standardized statewide based on roadway functional classification, number of lanes, median type, and urban/rural type. Also, in Round 1, the SOE scale thresholds were averaged across SOE categories. It has since been determined that the SOE scale thresholds for each category should be applied separately rather than using combined average SOE scale thresholds across categories. More information on the similar operating environments is provided in the Safety performance area methodology write-up.
- Hot spot mapping – Round 1 introduced the concept of crash hot spot mapping, but the thresholds for the hot spots were unique to each corridor. For Round 2, a standardized hot spot threshold of 0.000000035 for the Equal Interval map symbology has been developed.
- Weighted 5-Year Annual Average Daily Traffic (AADT) Volumes – The 5-year AADT average value was calculated as a straight average in Round 1. For Round 2, the 5-year AADT average value calculation has been modified to be a weighted average based on length.

- Safety Index scale inversion – The Safety Index scale has been inverted so that higher values equate to worse performance, as this is how safety performance is generally reported (e.g., higher crash frequency or rate typically means worse safety performance).
- Safety Index by direction – A new secondary performance measure has been developed that splits out the safety index by direction instead of having both directions combined. Directionality is assigned based on the Unit Direction of Travel in the crash data.
- Sample size constraints on secondary performance measures – A new methodology has been developed that screens out secondary performance measures on a segment- or corridor-basis if the sample size is considered too small for use in safety performance evaluation. Screened out segments are noted as having “insufficient data”. More information on the sample size screening for secondary performance measures is provided in the Safety performance area methodology write-up.

E. Freight

- TTTI/TPTI on Interrupted Flow facilities – The Truck TTI (TTTI) and Truck PTI (TPTI) on interrupted flow facilities have been updated to use the same adjusted thresholds discussed previously for TTI and PTI in the Mobility performance area, which are:

Table E-1: TTTI and TPTI Performance Thresholds for Uninterrupted Flow Facilities

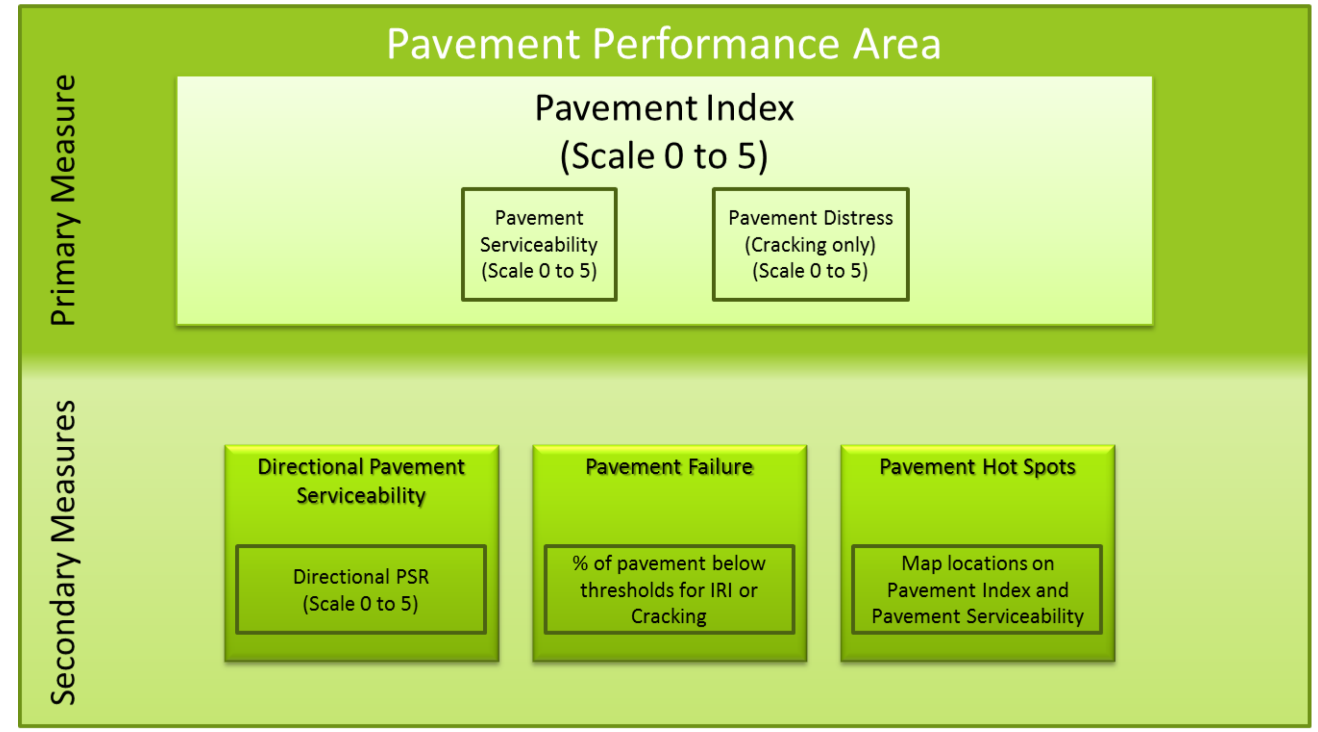
Performance Level	TTTI	TPTI
Good	<1.15	<1.3
Fair	1.15 - 1.33	1.3 - 1.5
Poor	>1.33	>1.5

Table E-2: TTTI and TPTI Performance Thresholds for Interrupted Flow Facilities

Performance Level	TTTI	TPTI
Good	<1.3	<2.0
Fair	1.3 - 2.0	2.0 - 4.0
Poor	>2.0	>4.0

Appendix B – Performance Area Detailed Calculation Methodologies

Pavement Performance Area Calculation Methodologies



<u>Primary Measure:</u>

The Pavement Index is calculated based on the use of two pavement condition ratings from the ADOT Pavement Database. The two ratings are the International Roughness Index (IRI) and the Cracking Rating. The calculation of the Pavement Index uses a combination these two ratings.

The IRI is a measurement of the pavement roughness based on field-measured longitudinal roadway profiles. To facilitate the calculation of the index, the IRI rating was converted to a Pavement Serviceability Rating (PSR) using the following equation:

$$PSR = 5 * e^{-0.0038*IRI}$$

The Cracking Rating is a measurement of the amount of surface cracking based on a field-measured area of 1,000 square feet that serves as a sample for each mile. To facilitate the calculation of the index, the Cracking Rating was converted to a Pavement Distress Index (PDI) using the following equation:

$$PDI = 5 - (0.345 * C^{0.66})$$

Both the PSR and PDI use a 0 to 5 scale with 0 representing the lowest performance and 5 representing the highest performance. The performance thresholds shown in the tables below were used for the PSR and PDI.

Table 1 - Performance Thresholds for Interstates

	IRI (PSR)	Cracking (PDI)
Good	<75 (>3.75)	<7 (>3.75)
Fair	75 - 117 (3.20 - 3.75)	7 - 12 (3.22 - 3.75)
Poor	>117 (<3.20)	>12 (<3.22)

Table 2 - Performance Thresholds for Non-Interstates

	IRI (PSR)	Cracking (PDI)
Good	<94 (>3.5)	<9 (>3.5)
Fair	94 - 142 (2.9 - 3.5)	9 - 15 (2.9 - 3.5)
Poor	>142 (<2.9)	>15 (<2.9)

- The PSR and PDI are calculated for each 1-mile section of roadway. If PSR or PDI falls into a poor rating (<3.2 for Interstates, for example) for a 1-mile section, then the score for that 1-mile section is entirely (100%) based on the lower score (either PSR or PDI). If neither PSR or PDI fall into a poor rating for a 1-mile section, then the score for that 1-mile section is based on a combination of the lower rating (70% weight) and the higher rating (30% weight). The end result is a score between 0 and 5 for each direction of travel of each mile of roadway based on a combination of both the PSR and the PDI.

The project corridor has been divided into segments. The Pavement Index for each segment is a weighted average of the directional ratings based on the number of travel lanes. Therefore, the condition of a section with more travel lanes will have a greater influence on the resulting segment Pavement Index than a section with fewer travel lanes.

The resulting Pavement Index (good/fair/poor) for each segment will be presented on a corridor map. In addition, the calculated Pavement Index for each segment will be presented in tabular format.

Secondary Measures:

Two secondary measures will be evaluated:

- Directional Pavement Serviceability
- Pavement Failure

Directional Pavement Serviceability: Similar to the Pavement Index, the Directional Pavement Serviceability will be calculated as a weighted average (based on number of lanes) for each segment. However, this rating will only utilize the PSR and will be calculated separately for each direction of travel. The PSR uses a 0 to 5 scale with 0 representing the lowest performance and 5 representing the highest performance. The resulting Directional Pavement Serviceability (good/fair/poor) for each direction of each segment will be presented on a corridor map. In addition, the calculated Directional Pavement Serviceability for each segment will be presented in tabular format.

Pavement Failure: The percentage of pavement area rated above the failure thresholds for IRI or Cracking will be calculated for each segment. The calculated percentage for each segment will be presented in a table. In addition, the Standard score (z-score) will be calculated for each segment.

The Standard score (z-score) is the number of standard deviations above or below the mean. Therefore, a Standard score between -0.5 and +0.5 is “average”, less than -0.5 is lower (better) than average, and higher than +0.5 is above (worse) average. The resulting Standard Score (better/average/worse) for each segment will be presented on a corridor map. The thresholds for this performance measure will be established once all corridors have done their calculations and provided the results to AECOM. AECOM will then calculate the standard score thresholds using data from all corridors.

Hot Spot Identification:

The Pavement Index map will identify locations that have an IRI rating or Cracking rating that fall above the failure threshold as identified by ADOT Pavement Group. For Interstates, an IRI rating above 105 or a Cracking rating above 15 will be used as the thresholds which are slightly different than the ratings shown in the table above. For non-Interstates, an IRI rating above 142 or a Cracking rating above 15 will be used as the thresholds. The locations will be identified by displaying a symbol on the map. A single symbol will be used to represent consecutive/adjacent sections. However, if there is a gap between the sections, then a second symbol will be displayed on the map.

The Directional Serviceability map will identify locations that have an IRI rating above 105 for Interstates or above 142 for non-Interstates by displaying a symbol and labeling the location. A single symbol will be used to represent consecutive/adjacent sections. However, if there is a gap between the sections, then a second symbol will be displayed on the map.

Data Entry:

1. Edit the data in Column A (add or delete rows and edit titles in Column A) to match the correct number of 1-mile sections within the segment and copy the formulas in columns B and D
2. Enter the beginning milepost for Mile 1 and the other mileposts should auto-calculate
3. Edit the titles in cells E-1, H-1, K-1, and M-1 to reflect the directions of travel
4. Copy and paste 2 pavement ratings (IRI and Cracking) for each 1-mile section into the appropriate cells; use the “paste values” command to not overwrite formatting
5. If the 1-mile section does not have a Cracking rating, enter 0.1 into the cell for Cracking
6. Enter the number of lanes for each 1-mile section into columns E and H; it is suggested that this number be a rounded approximation and not based on as-builts
7. If rows are added, copy the formulas
8. If the formatting doesn’t work, use the “format painter” tool to copy the formatting from other cells

Calculations:

1. Columns K through N calculate the PSR and PDI for each 1-mile section for each direction of travel

2. Columns O and P calculate a composite rating for each 1-mile section based on a combination of PSR and PDI
3. The weighted average Pavement Index (weighted by number of lanes) is calculated in Column Q
4. The weighted average PSR (weighted by number of lanes) is calculated in Columns K and M
5. The % of pavement above the thresholds for failure is calculated in Column S

Resulting Values and Presentation:

1. Pavement Index rating for each segment (good/fair/poor) presented on map with symbol at locations of failing pavement (either IRI or Cracking)
2. Pavement Index score presented in table
3. Directional Pavement Serviceability for each segment in each direction (good/fair/poor) presented on map with symbol at locations that have an IRI above 105 for Interstates or above 142 for non-Interstates
4. Directional Pavement Serviceability score presented in table
5. % Failing Pavement; % presented in table; Standard score presented on map.

Scoring:

	Pavement Index	
	Interstates	Non-Interstates
Good	>3.75	>3.5
Fair	3.2 - 3.75	2.9 - 3.5
Poor	<3.2	<2.9

	Directional Pavement Serviceability	
	Interstates	Non-Interstates
Good	>3.75	>3.5
Fair	3.2 - 3.75	2.9 - 3.5
Poor	<3.2	<2.9

Standard Score (1)	
Better	< -0.5
Average	-0.5 – +0.5
Worse	>+0.5

(1) The Standard score (z-score) is based on the % of pavement rated above failure threshold for each segment. The thresholds for this performance measure will be established once all corridors have done their calculations and provided the results to AECOM. AECOM will then calculate the standard score thresholds using data from all corridors.

Example Calculation for Pavement Performance Area:

See the attached example for the Pavement Performance Area.

Steps 1 and 2

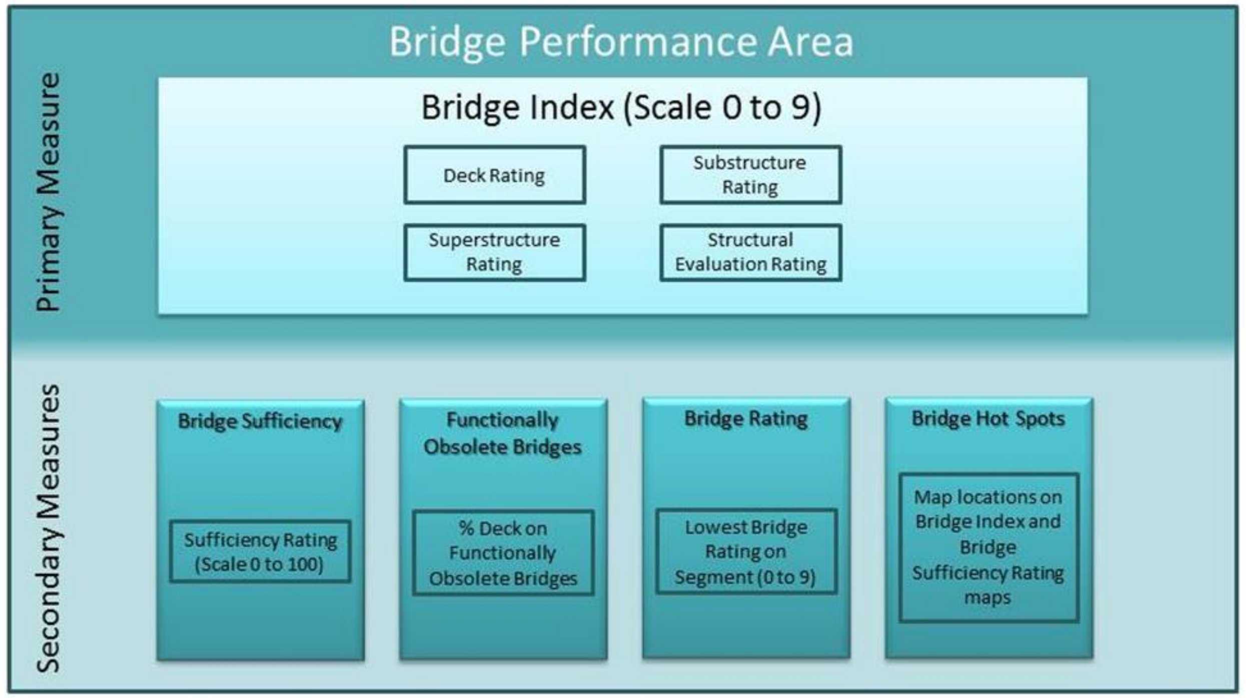
Step 3

				Northbound			Southbound			NB		SB		Composite		Pavement Index	IRI > 105 or Cracking >16	
				# of Lanes	IRI	Cracking	# of Lanes	IRI	Cracking	PSR	PDI	PSR	PDI	NB	SB		NB	SB
Segment 7																		
Mile 1	279	to	280	2	46.99	2	2	71.18	2	4.18	4.5	3.82	4.5	4.26	4.01		0	0
Mile 2	280	to	281	2	82.52	0	2	71.30	1	3.65	5.0	3.81	4.7	4.06	4.07		0	0
Mile 3	281	to	282	2	123.62	6	2	119.96	6	3.13	3.9	3.17	3.9	3.13	3.17		2	2
Mile 4	282	to	283	2	66.04	0	2	35.94	4	3.89	5.0	4.36	4.1	4.22	4.21		0	0
Mile 5	283	to	284	2	79.02	2	2	39.95	1	3.70	4.5	4.30	4.7	3.93	4.40		0	0
Mile 6	284	to	285	2	49.58	3	2	50.48	7	4.14	4.3	4.13	3.8	4.19	3.87		0	0
Mile 7	285	to	286	2	73.18	1	2	48.68	1	3.79	4.7	4.16	4.7	4.05	4.31		0	0
Mile 8	286	to	287	2	74.66	20	2	70.51	1	3.76	2.5	3.82	4.7	2.51	4.07		2	0
Mile 9	287	to	288	2	76.55	1	2	71.66	0	3.74	4.7	3.81	5.0	4.01	4.17		0	0
			Total	18			18											6
			Weighted Average							3.78	4.32	3.93	4.43	3.82	4.03			
			Factor							1.00		1.00						
			Indicator Score							**3.78**		**3.93**						**16.7%**
			Pavement Index													**3.92**		

Steps 4 and 5

Step 6

Bridge Performance Area Calculation Methodologies



This performance area is used to evaluate mainline bridges. Bridges on ramps (that do not cross the mainline), frontage roads, etc. should not be included in the evaluation. Basically, any bridge that carries mainline traffic or carries traffic over the mainline should be included and bridges that do not carry mainline traffic, run parallel to the mainline (frontage roads), or do not cross the mainline should not be included.

<u>Primary Measure:</u>

The Bridge Index is calculated based on the use of four bridge condition ratings from the ADOT Bridge Database, also known as the Arizona Bridge Information and Storage System (ABISS). The four ratings are the Deck Rating (N58), Substructure Rating (N60), Superstructure Rating (N59), and Structural Evaluation Rating (N67). The calculation of the Bridge Index uses the lowest of these four ratings.

Each of the four condition ratings use a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. As defined by ADOT Bridge Group, a rating of 7 or above represents “good” performance, a rating of 5 or 6 represents “fair” performance, and a rating of 4 or below represents “poor” performance.

The project corridor has been divided into segments and the bridges are grouped together according to the segment definitions. In order to report the Bridge Index for each corridor segment, the Bridge Index for each segment is a weighted average based on the deck area for each bridge. Therefore, the condition of a larger bridge will have a greater influence on the resulting segment Bridge Index than a smaller bridge.

The resulting Bridge Index (good/fair/poor) for each segment will be presented on a corridor map. In addition, the calculated Bridge Index for each segment will be presented in tabular format.

<u>Secondary Measures:</u>

Three secondary measures will be evaluated:

- Bridge Sufficiency Rating
- Bridge Rating
- Functionally Obsolete Bridges

Bridge Sufficiency Rating: Similar to the Bridge Index, the Bridge Sufficiency Rating will be calculated as a weighted average (based on deck area) for each segment. The Sufficiency Rating is a scale of 0 to 100 with 0 representing the lowest performance and 100 representing the highest performance. A rating of 80 or above represents “good” performance, a rating between 50 and 80 represents “fair” performance, and a rating below 50 represents “poor” performance. The resulting Sufficiency Rating (good/fair/poor) for each segment will be presented on a corridor map. The calculated Sufficiency Rating for each segment will be presented in tabular format.

Bridge Rating: The Bridge Rating will simply identify the lowest bridge rating on each segment. This performance measure is not an average and therefore is not weighted based on the deck area. The Bridge Index identifies the lowest rating for each bridge, as described above. This secondary performance measure will simply identify the lowest rating on each segment. Each of the four condition ratings use a 0 to 9 scale with 0 representing the lowest performance and 9 representing the highest performance. As defined by ADOT Bridge Group, a rating of 7 or above represents “good” performance, a rating of 5 or 6 represents “fair” performance, and a rating of 4 or below represents “poor” performance. The resulting Bridge Rating (good/fair/poor) for each segment will be presented on a corridor map. The Bridge Rating for each segment will be presented in tabular format.

Functionally Obsolete Bridges: The percentage of deck area on functionally obsolete bridges will be calculated for each segment. The deck area for each bridge within each segment that has been identified as functionally obsolete will be totaled and divided by the total deck area for the segment to calculate the percentage of deck area on functionally obsolete bridges for each segment. The calculated percentage for each segment will be presented in tabular format. In addition, the Standard score (z-score) will be calculated for each segment.

The Standard score (z-score) is the number of standard deviations above or below the mean. Therefore, a Standard score between -0.5 and +0.5 is “average”, less than -0.5 is lower (better) than average, and higher than +0.5 is above (worse) average. The resulting Standard Score (better/average/worse) for each segment will be presented on a corridor map. The thresholds for this performance measure will be established once all corridors have done their calculations and provided the results to AECOM. AECOM will then calculate the standard score thresholds using data from all corridors.

<u>Hot Spot Identification:</u>

The Bridge Index map will identify individual bridge locations that are rated as Structurally Deficient (rating of 4 or less)(identified as “S” in column labeled Deficiency Classification) by displaying a symbol and labeling the location. In addition, individual bridge locations that have multiple ratings of 5 will also be shown as a hot spot.

The Sufficiency Rating map will identify individual bridge locations that have a Sufficiency Rating less than 50 by displaying a symbol and labeling the location.

<u>Data Entry:</u>

9. Copy and paste bridge names (A209) in rows for each segment; use the “paste values” command to not overwrite formatting
10. Copy and paste 4 bridge ratings (N58, N59, N60, N67) for each bridge into the appropriate cells; use the “paste values” command to not overwrite formatting; values in bridge file are input as “general”

format so after the values are pasted into the cells, they need to have their format converted to "numbers"

11. Copy and paste Sufficiency Rating (SufficiencyRating) for each bridge into the appropriate cells in Column E; use the "paste values" command to not overwrite formatting
12. Copy and paste Deck Area (A225) for each bridge into the appropriate cells in Column D; use the "paste values" command to not overwrite formatting
13. If the bridge has been identified as Functionally Obsolete (identified as "F" in in column labeled DeficiencyClassification), manually enter the deck area in column K
14. If rows are added, copy the formulas
15. If the formatting doesn't work, use the "format painter" tool to copy the formatting from other cells

Note: Only enter data for the mainline bridges. Bridges on ramps, frontage roads, etc. should not be used. In addition, structures with "SPP" or "RCB" in the name (A209) should not be entered.

Calculations (automated):

6. Column D is the deck area and the values are added together to get a total deck area for the segment.
7. Columns F through I are the 4 bridge ratings; column J identifies the lowest value from the 4 bridge ratings
8. The weighted average Sufficiency Rating (weighted by deck area) and the weighted average Condition Rating (weighted by deck area) are calculated
9. Column L identifies the lowest rating in each segment.

Resulting Values and Presentation:

6. Bridge Index rating for each segment (good/fair/poor) presented on map with symbol at locations that are structurally deficient
7. Bridge Index scores presented in table
8. Sufficiency Rating for each segment (good/fair/poor) presented on map with symbol at locations that have a Sufficiency Rating less than 50
9. Sufficiency Rating scores presented in table
10. Bridge Rating for each segment (good/fair/poor) presented on map with symbol at locations that are structurally deficient
11. Bridge Rating scores presented in table
12. % Bridge Deck Area on Functionally Obsolete Bridges; % presented in table; Standard score presented on map.

Scoring:

Bridge Index	
Good	>6.5
Fair	5.0-6.5
Poor	<5.0

Sufficiency Rating	
Good	>80
Fair	50-80
Poor	<50

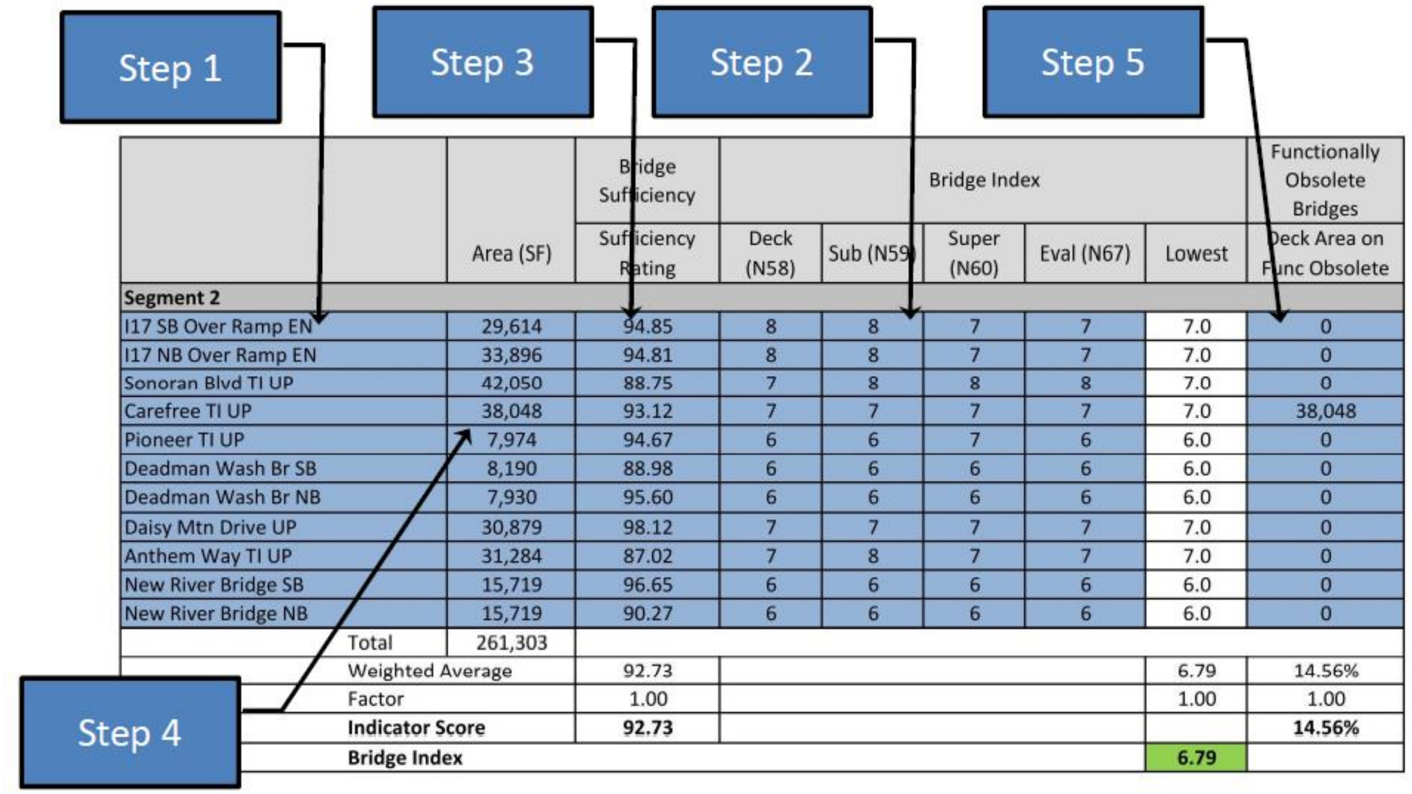
Bridge Rating	
Good	>6
Fair	5-6
Poor	<5

Standard Score (1)	
Better	< -0.5
Average	-0.5 – +0.5
Worse	>+0.5

(2) The Standard score (z-score) is based on the % of deck area on Functionally Obsolete Bridges for each segment

Example Calculation for Bridge Performance Area:

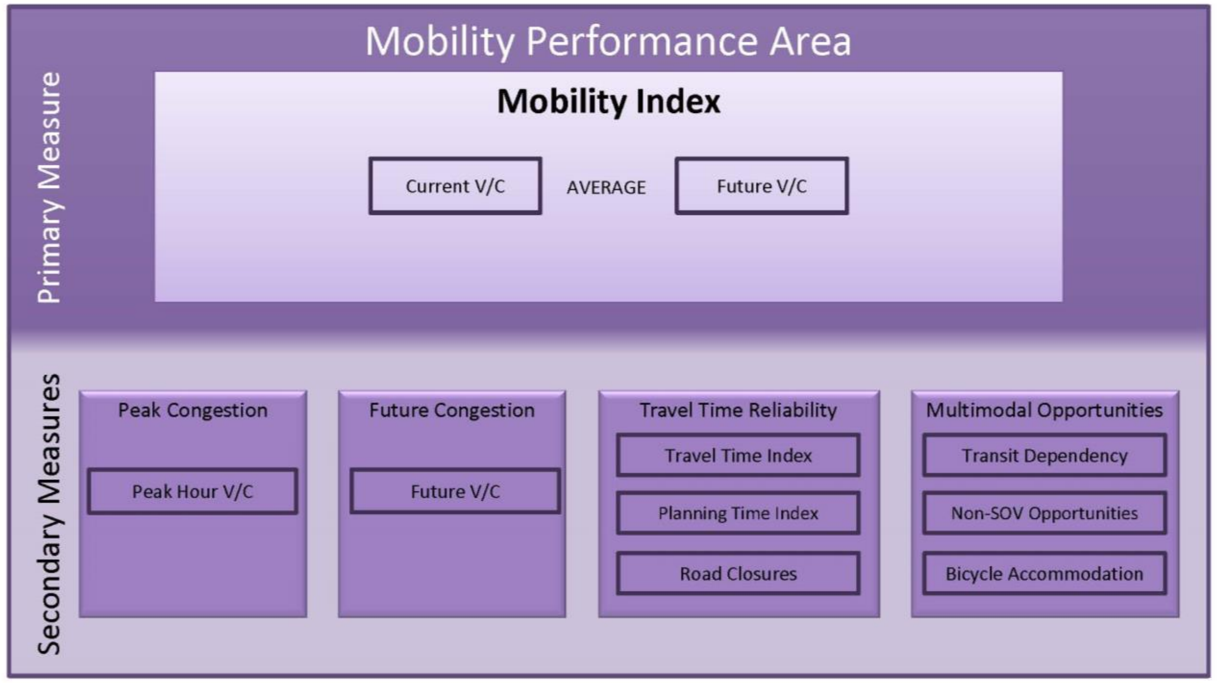
See the attached example for the Bridge Performance



	Area (SF)	Bridge Sufficiency: Sufficiency Rating	Bridge Index: Deck (N58)	Sub (N59)	Super (N60)	Eval (N67)	Lowest	Functionally Obsolete Bridges: Deck Area on Func Obsolete
Segment 2								
I17 SB Over Ramp EN	29,614	94.85	8	8	7	7	7.0	0
I17 NB Over Ramp EN	33,896	94.81	8	8	7	7	7.0	0
Sonoran Blvd TI UP	42,050	88.75	7	8	8	8	7.0	0
Carefree TI UP	38,048	93.12	7	7	7	7	7.0	38,048
Pioneer TI UP	7,974	94.67	6	6	7	6	6.0	0
Deadman Wash Br SB	8,190	88.98	6	6	6	6	6.0	0
Deadman Wash Br NB	7,930	95.60	6	6	6	6	6.0	0
Daisy Mtn Drive UP	30,879	98.12	7	7	7	7	7.0	0
Anthem Way TI UP	31,284	87.02	7	8	7	7	7.0	0
New River Bridge SB	15,719	96.65	6	6	6	6	6.0	0
New River Bridge NB	15,719	90.27	6	6	6	6	6.0	0
Total	261,303							
Weighted Average		92.73					6.79	14.56%
Factor		1.00					1.00	1.00
Indicator Score		**92.73**						**14.56%**
Bridge Index							**6.79**	

Mobility Performance Area Calculation Methodologies

This Appendix summarizes the approach and methodology to develop the primary and secondary performance measures in the Mobility Performance Area as shown in the following graphic.



<u>Primary Measure</u>

The primary Mobility Index is an average of the current volume to capacity (V/C) ratios and the projected future V/C ratios for each segment throughout the corridor.

<u>Current V/C</u>

The current V/C ratio for each segment is calculated by dividing the 2013 Annual Average Daily Traffic (AADT) volume for each segment by the total Level of Service (LOS) E capacity volume for that segment

The capacity (C) is calculated using the HERS Procedures for Estimating Highway Capacity[1]. The HERS procedure incorporates HCM 2010 methodologies. The methodology includes capacity estimation procedures for multiple facility types including freeways, rural two-lane highways, multilane highways, and signalized urban sections.

The segment capacity is defined as a function of the number of mainline lanes, shoulder width, interrupted or uninterrupted flow facilities, terrain type, percent of truck traffic, and the designated urban or rural environment.

1 HERS Support – 2011, Task 6: Procedures for Estimating Highway Capacity, draft Technical Memorandum. Cambridge Systematics. Prepared for the Federal Highway Administration. March 2013.

The AADT (V) for each segment is calculated by applying a weighted average across the length of the segment based on the individual 24 hour volumes and distances associated with each HPMS count station within each segment.

The following example equation was used to determine the weighted average of a segment with two HPMS count locations within the corridor

((HPMS 1 Distance x HPMS 1 Volume) + (HPMS 2 Distance x HPMS 2 Volume))/Total Segment Length

<u>Freeway Segments Capacity</u>

As presented in the *HERS Procedure for Estimating Highway Capacity*, the methodology for estimating a freeway segment capacity follows a process similar to HCM 2010. The process is as follows:

1. Compute the free-flow speed (FFS)

$$FFS = (75.4 - f_{LW} - f_{LC} - 3.22TRD^{0.84})$$

Where:

$f_{LW} = adjustment\ for\ lane\ width;$

$f_{LC} = adjustment\ for\ right-side\ lateral\ clearance; and$

$TRD = total\ ramp\ density$

2. Determine Base Capacity

$$BaseCapacity = 1{,}700 + 10FFS; for\ FFS \leq 70$$

$$BaseCapacity = 2{,}400; for\ FFS > 70$$

3. Adjust Base Capacity for Prevailing Demand Conditions

$$ActualCapacity = BaseCapacity * N * PHF * f_{HV}$$

Where:

$N = number\ of\ lanes\ in\ one\ direction;$

$PHF = peak\ hour\ factor;$ and

$f_{HV} = adjustment\ factor\ for\ heavy\ vehicles$

Rural Two-Lane Capacity

The HERS methodology for estimating capacity on a rural two-lane highway is as followed:

1. Using HCM 2010 equation 15-3, it is assumed that LOS "E" is a segment's operating capacity. Under LOS "E" conditions, an average travel speed (ATS) of 40 MPH can be used to solve for the capacity. The equation to solve for the service volume at LOS E is as followed:

$$V_{LOS\,E} = \frac{a(FFS - 40 - f_{np})}{0.00776}$$

Where:

$V_{LOS\,E}$ = $Two - way\ capacity;$

f_{NP} = $adjustment\ factor\ for\ no - passing\ zones$

a = $PHF * f_g * f_H;$

PHF = $peak\ hour\ factor;$

f_g = $adjustment\ factor\ for\ grades;$

f_{HV} = $adjustment\ factor\ for\ heavy\ vehicles;and$

2. Calculate the FFS

$$FFS = BFFS - f_{LS} - f_A$$

Where:

$BFFS$ = $Base\ free\ flow\ speed;$

f_{LS} = $adjustment\ factor\ for\ lane\ and\ shoulder\ width;and$

f_A = $adjustment\ factor\ for\ access\ points\ per\ mile$

Future V/C

The future V/C ratio for each segment is calculated by dividing the 2035 AADT volume for each segment by the 2013 LOS E capacity. The capacity volume used in this calculation is the same as was utilized in the current V/C equation.

The future AADT volumes are generated by applying an annual compound growth rate (ACGR) to each 2013 AADT segment volume. The following equation was used to apply an annual compound growth rate:

2035 AADT = 2013 AADT x ((1+ACGR)^22)

The ACGR for each segment was defined by comparing the total volumes in the 2010 Arizona Travel Demand Model (AZTDM2) to the 2035 AZTDM2 traffic volumes at each existing HPMS count station location throughout the corridor. Each 2010 and 2035 segment volume was defined using the same weighted average equation described in the *Current V/*C section above then summing the directional volumes for each location. The following equation was used to determine the ACGR for each segment:

ACGR = ((2035 Volume/2010 Volume)^(1/25))-1

Primary Index Data Entry

The following describes the inputs and steps required to calculate the Primary Index and appropriate secondary measures.

If the corridor is an interstate freeway, use the "*Freeway_Mobility_Index*" spreadsheet. If the corridor is a non-access controlled highway with both uninterrupted and interrupted flow facilities, use the "*Highway_Mobility_Index*" spreadsheet.

Note that the following steps indicate if the input applies to an interstate freeway or to a non-access controlled highway corridor. If it is not indicated, the inputs apply to both spreadsheets.

1. In tab 'HPMS Report 2013R,' use the filter function in Column 'C' to show all records for your respective corridor.
2. In tab 'HPMS Report 2013R,' copy all records for Columns A (Loc ID), D (BMP), G (EMP), J (Pos Dir AADT), K (Neg Dir AADT) , L (AADT 2013), P (K Factor), Z (T-Factor), and Q (D-Factor)
   Note: If the directional AADT values are not provided for a specific HPMS count location, apply the average ratio of the upstream and downstream HPMS count location directional values to their respective two way value.
3. Paste copied values into appropriate columns in tab '2013 HPMS'.
4. On tab '2013 HPMS' in columns B, C, and D input corridor specific information for each respective segment.
5. On tab '2013 HPMS' in columns E, F, G, H, I, J, K, and L apply the weighted average formula referenced in the *Current V/C* section to each count location in each corridor segment to calculate the corresponding segment values for the following data:
   a. 2013 AADT (Column E)
   b. NB AADT (Column F)
   c. SB AADT (Column G)
   d. K Factor (Column H)
   e. NB K-Factor (Column I)
   f. SB K-Factor (Column J)
   g. T-Factor (Column K)

h. D-Factor (Column L)

Note: Adjust the formulas saved in columns E through G for the appropriate number of count stations in each segment. Column I (AADT 2013) on 'Mobility Index' tab will auto populate with appropriate values.

6. On tab 'Mobility Index' define the following for the specific corridor type in each segment:
   a. **Freeway Facility:** Environment Type (Column F), Terrain (Column G), Number of Lanes (Column H), Average Lane Width (Column I), Directional Right Shoulder Width (Column J and K)
   b. **Highway Facility (interrupted and uninterrupted flow):** Environment Type (Column F), Terrain (Column G), Facility Type (Column H), Posted Speed Limit (Column H), Number of Lanes (Column J), Average Lane Width (Column K), Average Shoulder Width (Column L), and Percent No-Passing Zones (Column M)

Below is a description of fields that may require additional processing to evaluate at the segment level.

Environment Type

c. **Urban** – Generally fully developed area, mile spaced TI's, and a 65 mph speed limit.
d. **Fringe Urban** – more than 5,000 populations not in an urban area, moderate levels of development and a speed limit that is transitioning from 65mph to faster speeds.
e. **Rural** – Less than 5,000 population, low levels of development, and a 75 mph speed limit

Terrain Type

a. **Level** – Any combination of geometric design elements that permits trucks to maintain speeds that equal or approach speeds of passenger cars. The HCM 2010 defines a segment as being level when grades are no more than 2%.
b. **Rolling** – Any combination of geometric design elements that causes trucks to reduce speed substantially below that of passenger cars on some sections of the highway but which does not involve sustained crawl speeds by trucks for a substantial distance.
c. **Mountainous** – Any combination of geometric design elements that will cause trucks to operate a crawl speed for considerable distances or at frequent intervals.

Average Shoulder Width

To approximate the average shoulder width for each segment, the ADOT data is input into the "Bicycle Accommodation" tab as both the Primary Index and Multi-Modal Opportunity share the same data processing (refer to the Bicycle Accommodation section).

No-Passing Zones

ADOT provides a statewide GIS dataset that identifies No-Passing Zones. Organize the data by segment either using a spreadsheet of GIS. Input the data can be input into the "No Passing Zone" tab and adjust the formulas for the specific segments.

7. Additional Input is required for the following corridor types:

   Freeway

   a. Estimate the total ramp density (TRD) by using **Table 4** in the "HERS Capacity Calc" tab. If the segment is rural, then TRD can be assumed to equal 0. Input the TRD for each segment in column N.

   Highway Facility

   a. Estimate the Access Points per Mile (Column N) for each segment.
   b. Using Table 3 in the "HERS Capacity Calc" tab input the adjustment factor for lane and shoulder width (Column Q).
8. On tab 'Mobility Index' the Capacity Volume LOS E will auto populate capacity values based on the calculations performed in the "HERS Capacity Calc" tab.
9. On tab 'HPMS Report 2013R' copy values in column F (TCS MP) and paste in column R (Milepost) on tab '2010'.
10. Using the 2010 AZTDM2 file provided by ADOT, identify the NB and SB total flow for each milepost location segment identified in Column R. Input values in Columns S and T on tab '2010'.
11. On tab '2010,' using the weighted average formulas saved in column D (Tot_Flow), identify the total segment volume for each corridor segment in each direction.
    Note: Adjust the formulas in column D to correspond to the number of milepost location data from the AZTDM2 as necessary.
12. On tab '2010,' using formula saved starting in Column D, Row 20, add NB and SB values to create a 2010 total flow value for each corridor segment.
13. On tab '2035' repeat steps 8, 9, and 10 using the 2035 AZTDM2 file provided by ADOT.
14. On tab '2010' copy formula as necessary to include all segment values in both 2010 and 2035 to calculate Annual Compound Growth Rate (highlighted in blue) for each segment.
15. On tab 'Mobility Index' columns O (AADT 2035), T (Current Segment V/C), AD (Future Segment V/C), and V (Avg V/C) will auto populate with based on saved formulas to provide the Primary Index values and ratings (green, yellow, red)

Primary Index Rating Thresholds

The following V/C thresholds were assigned for each environment type as indicated based on current ADOT roadway design standards.

Urban and Fringe Urban

Good - LOS A-C	V/C ≤ 0.71
Fair - LOS D	V/C > 0.71 & ≤ 0.89
Poor - LOS E or less	V/C > 0.89

*Note - ADOT Roadway Design Standards indicate Urban and Fringe Urban roadways should be designed to level of service C or better

Rural

Good - LOS A-B	V/C ≤ 0.56
Fair - LOS C	V/C > 0.56 & ≤ 0.76
Poor - LOS D or less	V/C > 0.76

*Note - ADOT Roadway Design Standards indicate Rural roadways should be designed to level of service B or better

Secondary Measures

Peak Congestion

Peak Congestion has been defined as the peak hour V/C ratio in both directions of the corridor. The peak hour V/C ratio is calculated by dividing the directional design hour volume (DHV) by the directional LOS E capacity volume as previously calculated using the HERS procedure. The DHV is calculated by applying the directional K Factor to the directional 24hr AADT for that segment. The directional AADT for each segment is calculated by applying a weighted average across the length of the segment based on the individual directional 24 hour volumes and distances associated with each HPMS count station within each segment.

Peak Hour Data Entry

1. On tab '2013 HPMS,' in columns U and V, using the online TDM tool at http://www.azdot.gov/planning/DataandAnalysis input the directional K factors for each HPMS location by referencing the number in the 'Loc ID' column for your corridor.

   Note: If the directional K values are not provided for specific a HPMS count location, apply the average ratio of the upstream and downstream HPMS count location directional values to their respective two way K factor value. On I-19, this formula is highlighted in cells where it occurred in yellow.

2. On tab '2013 HPMS,' columns I (NB K) and J (SB K) will auto fill based on the weighted average formula saved in those cells.

   Note: Adjust formulas as needed to account from the appropriate number of input values for each segment. In cases where the directional K factors from ADOT data seem inconsistent with the upstream or downstream count stations, omit or augment data as necessary in an effort to provide an accurate reflection of the total segment directional K factors.

3. On tab 'Mobility Index,' Columns X (NB DHV), Y (NB Capacity LOS E), Z (Current NB Peak V/C), AA (SB DHV), AB (SB Capacity LOS E), and AC (Current SB Peak V/C) will all auto fill based on saved formulas in those cells to provide the directional V/C ratios and threshold ratings (green, yellow, red).

Peak Congestion Rating Thresholds

The same thresholds identified for the 24hr V/C ratios were applied to the Peak Congestion V/C values.

Future Congestion

The future V/C ratios for each segment in the corridor that were calculated and used in the Primary Mobility Index as part of the overall average between Current V/C and Future V/C were applied independently as a secondary measure. The methods to calculate the Future V/C can be referenced in the Primary Mobility Index section.

Travel Time Reliability

Travel time reliability is a measure that includes the number of times a piece of a corridor is closed for any specific reason, the directional Travel Time Index (TTI), and the Planning Time Index (PTI).

Directional Closures

The number of times a roadway is closed is documented through the HCRS dataset. Directional Closures was defined as the average number of times a segment of the corridor was closed per year mile in a specific direction of travel per year. The weighted average of each occurrence takes into account the distance over which a specific occurrence spans.

Note: Where closures occur over a distance that spans segment boundaries make sure to include the appropriate distance in each segment. This will require adding an entry into the dataset. For example, if a closure occurs at milepost 10 in a segment that ends at milepost 12 and spans 4 miles you will account for a 2 mile closure in each adjoining segment.

Directional Closures Data Entry

1. Using the 'hcrs_FullClosures_rev4_statewide averages' dataset provided, copy and paste every column of data for ONLY your corridor into the full Mobility Index workbook tab 'HCRS 2009-2013.'
   Note: Make sure to match column headings from each file before copying data from original file.
2. In tab 'HCRS 2009-2013,' sort Column S (hwy_at_mp) from smallest to largest value.
3. Using the milepost location identified in Column S, input the appropriate segment location for each incident in Column R (Segment) in order to breakdown how many closures occurred in each corridor segment.
4. On tab 'Mobility Index' columns W and X will auto fill the average number of incidents that have occurred per mile per year within each segment.

Directional Closures Thresholds

Thresholds that determine levels of good, fair, and poor are based on the average number of closures per mile per year within each of the nine identified statewide significant corridors by ADOT. The following thresholds represent statewide averages cross those corridors:

Good	≤ 0.38
Fair	> 0.38 & ≤ 1.46
Poor	V/C > 1.46

Directional Travel Time and Planning Time Index

In terms of overall mobility, the travel time index (TTI) is the relationship of the posted speed limit in a specific section of the corridor to the mean peak hour speed in the same location. The planning time index (PTI) is the relationship of the 5th percentile of the lowest mean speed to the posted speed limit in a specific section of the corridor. Using HERE data provided by ADOT, four time periods for each data point were collected throughout the day (AM Peak, Mid-Day, PM Peak, and Off-peak). Using the mean speeds and 5th percentile lowest mean speeds collected over 2013 for these time periods for each data location, four TTI and PTI calculations were made using the following formulas:

TTI = Posted Speed Limit/Mean Peak Hour Speed

PTI = Posted Speed Limit/5th Percentile Lowest Speed

The highest value of the four time periods calculation was defined as the TTI for that data point. The average TTI was calculated within each segment based on the number of data points collected. The value of the average TTI across each entry was used as the TTI for each respective segment within the corridor.

Data Entry for Directional TTI and PTI

1. Using the 'Congestion Metrics' file provided by ADOT, filter and sort column D on Sheet 1 to show only your corridor.
2. Using the 'Arizona_FHWA_Monthly_Static_File_Q22013' file, link the two spreadsheets together using the common TMC data column into a new combined file.
3. In the new combined file, associate each record to a segment based on location within the corridor using the Latitude/Longitude coordinates provided. Organize by direction within each segment.
   Note: Each directional location will have four data records (AM Peak, Mid-day, PM Peak, Off Peak).
4. On tab 'PTI_TTI Calculations' in Mobility Index workbook, copy values from combined workbook to the columns A through I with the same headings.
5. Using the 'SpeedLimit' GIS file, identify the posted speed limit for each record location throughout each segment and input values into Column P (Speed_Limit) on the 'PTI_TTI_Calculations' tab in the Mobility Index workbook.
6. On tab 'PTI_TTI_Calculations' columns J through O should auto fill. Extend formulas as necessary based on the number of records for each segment.
7. On 'Mobility Index' tab, columns Y, Z, AA, and AB should auto fill based on values and ratings as indicated.

Multimodal Opportunities

Transit Dependency

2008-2012 U.S. Census American Community Survey tract and state level geographic data and attributes from the tables B08201 (Number of Vehicles Available by Household Size) and B17001 (Population in Poverty within the Last 12 Months) were downloaded with margins of error included from the Census data retrieval application Data Ferret. Population ranges for each tract were determined by adding and subtracting the margin of error to each estimate in excel. The tract level attribute data was then joined to geographic tract data in GIS. Only tracts within a one mile buffer of each corridor are considered for this evaluation.

Tracts that had a statistically significantly larger number of either people in poverty or households with only one or no vehicles available than the state average was considered potentially transit dependent.

Example: The state average for Zero or One Vehicles HHs is between 44.1% and 45.0%. Tracts which have the LOWER bound of their range above the UPPER bound of the state range definitely have a greater percentage of zero/one vehicle HHs than the state average. Tracts that have their UPPER bound beneath the LOWER bound of the state range definitely have a lesser percentage of zero/one vehicles HHs than the state average. All other tracts that have one of their bounds overlapping with the state average cannot be considered statistically significantly different because there is a chance the value is actually the same.

Transit Dependency Rating Methodology

Tracts with both zero and one vehicle household and population in poverty percentages below the statewide average

Tracts with either zero and one vehicle household OR population in poverty percentages within the statewide average

Tracts with both zero and one vehicle household and population in poverty percentages above the statewide average

In addition to transit dependency, the following attributes were added to the Multimodal Opportunities map based on available data.

1. Shoulder width throughout the corridor based on 'Shoulder Width' GIS dataset provided by ADOT.
2. Intercity bus routes
3. Multiuse paths within the corridor ROW if applicable

% Non SOV Trips

The percentage of non-single occupancy vehicle trips over distances less than 50 miles gives an indication of travel patterns along a section of the corridor that could benefit from additional multimodal options in the future.

% Non-SOV Trips Data Entry

1. Using the 2010 AZTDM2 file provided by ADOT, export your corridor model files to an excel workbook.
2. Copy values from output file and paste into appropriate columns with the same name on tab 'Non SOV Short Trips_raw.' Yellow highlighted cells will auto fill based on inputs. **Do not paste any values into yellow highlighted cells.**
3. On tab '2010' in the Mobility Index workbook, input Direction, ID, and SEG values associated with your corridor from the AZTDM2 output file. Organize by segment as shown in I-19 example file.
   Note: Copy formulas as needed based on number of records in each segment.
4. On tab '2010' Column E, J, K and L will auto fill based on raw data input.
5. On tab 'Mobility Index' Column AD will autofill and ratings will be assigned based conditional formatting to the appropriate threshold.
   Note: Thresholds will be finalized upon determination of statewide averages for Non-SOV trips. This data has been requested from ADOT and will be provided upon receipt.

% Non-SOV Thresholds
Thresholds that determine levels of good, fair, and poor are based on the % Non SOV trips within each of the nine identified statewide significant corridors by ADOT. The following thresholds represent statewide averages cross those corridors:

Good	≥ 17%
Fair	> 11% & ≤ 17%
Poor	< 11%

Bicycle Accommodation

For this secondary performance evaluation, shoulder widths are evaluated considering the roadway's context and conditions. This requires use of the roadway data that includes right shoulder widths, shoulder surface types, and speed limits. All of which are available in the following ADOT GIS data sets:

- Right Shoulder Widths
- Left Shoulder Widths (for undivided roadways)
- Shoulder Surface Type (Both Left/Right)
- Speed Limit

Additionally, each segment's average AADT, estimated earlier in the Mobility methodology, will be used for the criteria to determine if the existing shoulder width meets the effective width.

The criteria for screening if a shoulder segment meets the recommended width criteria are as followed:

(1) If AADT <= 1500 OR Speed Limit <= 25 MPH:

The segment's general purpose lane can be shared with bicyclists (no effective shoulder width required)

(2) If AADT > 1500 AND Speed Limit between (25 - 50 MPH) AND Pavement Surface is Paved:

Effective shoulder width required is 4 feet or greater

(3) If AADT > 1500 AND Speed Limit >= 50 MPH And Pavement Surface is Paved:

Effective shoulder width required is 6 feet or greater

The summation of the length of the shoulder sections that meet the defined effective width criteria, based on criteria above, will be divided by the segments total length to estimate the percent of the segment that accommodates bicycles as illustrated below with the following thresholds.

Segment	% Bicyle Accomodation
95-1	62%
95-2	56%
95-3	8%
95-4	0%
95-5	2%
95-6	87%
95-7	0%
95-8	25%
95-9	61%
95-10	2%
95-11	0%
95-12	9%
95-13	71%

Bicylce Accomodation Thresholds

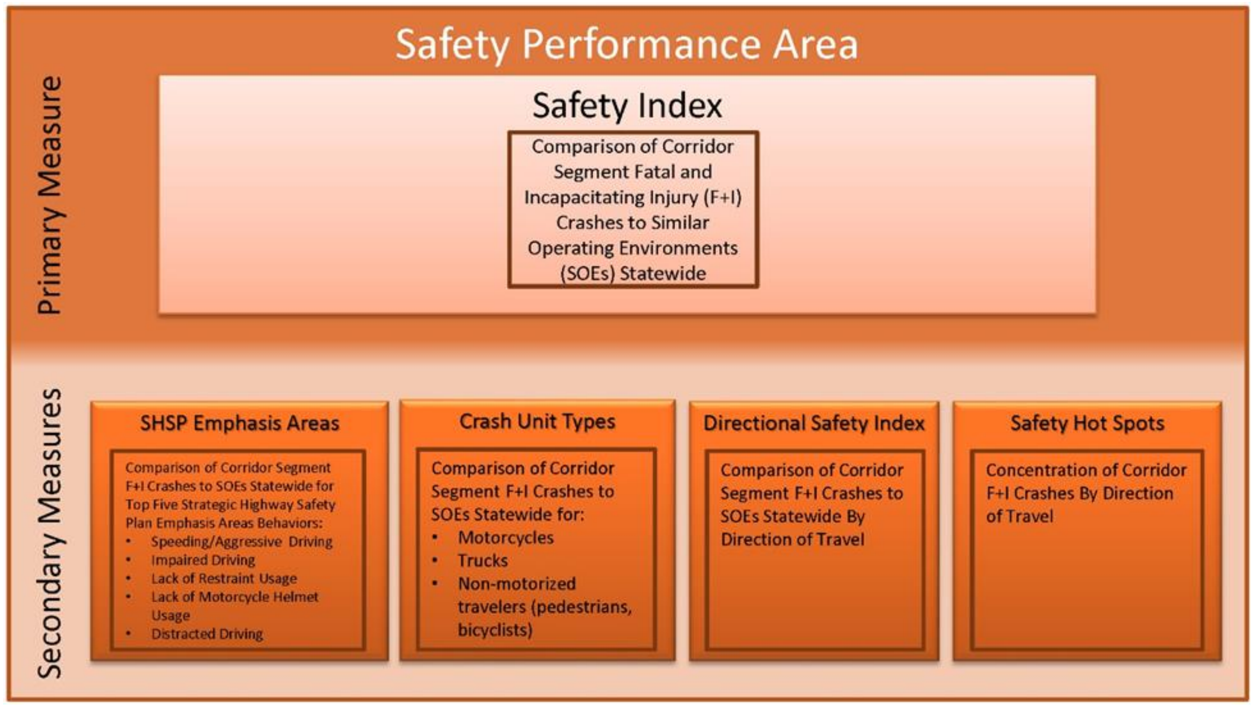
Good	>= 90
Fair	< 90 & >= 60
Poor	< 60

1. Using ArcMap, filter the study corridor for each of the GIS following shapefiles:
   a. Right Shoulder Widths
   b. Left Shoulder Widths (Undivided roadways)
   c. Shoulder Surface Type (Both Left/Right)
   d. Speed Limit
2. For divided highways or interstates, the Right Shoulder Width data will be adequate. Undivided highways will require the use of both the Left/Right Shoulder Width data as the links are bi-directional and the Left Shoulder Width represents the right shoulder in the non-cardinal direction.
3. Using a combination of the Buffer and Identity tool within ArcMap, the Shoulder Surface Type and Speed Limit can be intersected with the Right/Left Shoulder Width data. The original features in the Right/Left Shoulder Width data will be split based on the overlap of the intersected data. Recalculate the features geometry length in miles.
4. Copy the appropriate intersected data attributes to the "Bicycle Accommodation" Tab in the Mobility Performance spreadsheet. Sort and organize the shoulder segments by MP (From_Measure and To_Measure) and direction.

5. The average shoulder length will be calculated by taking the average of the beginning shoulder width and ending shoulder width, if a difference between the two exists.
6. Input the segments average AADT.
7. The criteria will be applied and a percentage that represents the amount adequate for bicycle use will be calculated for each segment. Adjust the formulas to evaluate the complete segments. Every corridor and segment will have unique shoulder width sections.

Safety Performance Area Calculation Methodologies

The Appendix summarizes the approach for developing the primary and secondary performance measures in the Safety Performance Area as shown in the following graphic.



General Instructions

The file entitled "SR-95 Safety Index - 09-07-15.xlsx" contains the 2010-2014 statewide fatal and incapacitating injury crash data set as well as statewide number of crashes and weighted average annual daily traffic (AADT) volumes for each of the similar operating environment (SOE) categories. If the analysis period for the corridor you are analyzing is 2010-2014, use the abbreviated instructions immediately below. Otherwise, use the more detailed instructions that follow that describe how to create information in a similar format to what is in the "SR-95 Safety Index - 09-07-15.xlsx" file.

Abbreviated Instructions *(for use with the "SR-95 Safety Index - 09-07-15.xlsx" file)*

<u>"Safety Performance Summary" Tab</u>

1. This tab references and summarizes information in the "F+I Crash Analysis Summary" tab for the overall Safety Index (the primary safety performance measure) as well as the secondary Safety performance measures. All data should be entered in the "F + I Crash Analysis Summary" and "5-Year Weighted AADT" tabs, not in the "Safety Performance Summary" tab.
2. Formula links and conditional formatting will need to be adjusted in the "Safety Performance Summary" tab depending on the number of Similar Operating Environments (SOE) in the corridor and which SOE applies to each segment of the corridor.

<u>"F + I Crash Analysis Summary" Tab</u>

1. Determine which Statewide SOEs apply to the various segments of the corridor being studied using the "Highway and Interstate SOEs" tab.
2. Copy and paste into the top part of the "F + I Crash Analysis Summary" tab the Statewide tables for those SOE categories found within the corridor from the "Statewide F+I Summary_WghtdAADT" tab. In the SR 95 example, the 2 or 3 Lane Undivided Highway and the 4 or 5 Lane Undivided Highway SOEs have been pasted in.
3. Develop similar tables below the Statewide SOE tables for the segments of the corridor being studied for each of the SOE categories, filling in the blue-shaded cells using the crash data in the "Corridor Crashes F+I" tab filtered to only show those crashes occurring within the corridor limits. The directional weighted AADT volume information that accounts for the proportion of each segment's length that pertains to each AADT value comes from the "5-Year Weighted AADT" tab.
4. If a corridor segment contains portions of multiple SOE categories, designate the corridor segment as the SOE category that covers the majority of the segment length. If there is no majority SOE category in a segment, designate the segment as the SOE category with the lowest statewide average crash frequency and rate values.
5. To fill in the corridor-specific bottom half of Column R (SHSP Top 5 Emphasis Areas) of the "F + I Crash Analysis Summary" tab, use Column AT (Emphasis) in the "Corridor Crashes F + I" tab and count how many crashes in the segment have a "Y" in that column.
6. To fill in the corridor-specific bottom half of Column T (Trucks), Column V (Motorcycles), and Column X (Non-Motorized Travelers) of the "F + I Crash Analysis Summary" tab, run queries on the corridor-specific crashes in the "Corridor Crashes F + I" tab that identify how many fatal and incapacitating injury crashes contain each of the field attributes listed below:
    - Truck-involved crashes – all UnitBodyStyleDesc codes that start with Truck;
    - Motorcycle-involved crashes – all UnitBodyStyleDesc codes that start with Motorcycle;
    - Non-motorized traveler-involved crashes – PersonTypeDesc codes of Pedestrian or Pedalcyclist.
7. This information then feeds into the "Crash % Indices" and "Safety Index" tabs. Formula links in the "Crash % Indices" and "Safety Index" tabs will need to be adjusted to make sure the appropriate Statewide SOE values are referenced for each segment of the corridor.

<u>"5-Year Weighted AADT" Tab</u>

1. Obtain the five years of AADT data that correspond to the crash data analysis period. This data is available on ADOT's Data and Analysis AADT webpage (http://azdot.gov/planning/DataandAnalysis).
2. Set up tables similar to the ones created here for SR-95 that list the count stations by Loc ID, BMP, EMP, and Length and paste in the bi-directional AADT as well as the directional AADT values. Where AADT values are missing (common for directional AADTs), use the adjacent count station's values or ratio of values as appropriate. Where directional AADTs are missing for several consecutive count stations, assume a 50/50 split of the overall AADT. Yellow highlighted cells indicate where the raw data either was not available or was modified to sum correctly.
3. Create formulas that calculate a weighted average AADT based on length for each corridor segment as shown in the smaller table for each year. The format of the tables and the most

current year of data should already have been created in the Mobility Index spreadsheet in the most current year HPMS tab.
4. This information then feeds into the table showing the weighted average AADTs for each segment, which goes into the "F + I Crash Analysis Summary" tab.

“Safety Index” Tab

1. This tab references and summarizes information in the "F+I Crash Analysis Summary" tab for the overall Safety Index (the primary safety performance measure) as well as the secondary Directional Safety Index.
2. Formula links and conditional formatting will need to be adjusted depending on the number of Similar Operating Environments (SOE) in the corridor and which SOE applies to each segment of the corridor.

“Crash % Indices” Tab

1. This tab references and summarizes information in the "F+I Crash Analysis Summary" tab for various secondary safety performance measures.
2. Due to the instability of small sample sizes, segment secondary performance measure levels that discuss crash types should be removed and replaced with "Insufficient Data" if any of the following criteria are met (this does not apply to the directional Safety Index):
   - a) adding or removing one fatal or incapacitating injury crash of the secondary performance measure type (e.g., SHSP Top 5, Truck) changes the segment performance measure value two levels (e.g., from Above Average (red color) to Below Average (green color) , regardless of the number of fatal + incapacitating injury crashes in the segment over the five-year analysis period);
   - b) there are fewer than five total fatal + incapacitating injury crashes (of any type) in a segment.
3. If the average segment crash frequency of the overall corridor is fewer than two fatal + incapacitating injury crashes of that secondary performance measure type over the five-year analysis period, the entire secondary performance measure should be eliminated from further analysis due to insufficient sample size. In the SR-95 example, the Truck, Motorcycle, and Non-Motorized secondary performance measures are eliminated due to insufficient sample size and some of the segments in the SHSP Top 5 Emphasis Areas Behaviors are eliminated due to insufficient sample size.
4. Update the conditional formatting of column E and the performance level value in column F to account for the "Insufficient Data" segments.

Detailed Instructions (for use with raw crash data sets)

Safety Index

To calculate the Safety Index, you will need to identify the fatal and incapacitating injury crashes that occur on each study corridor segment as well as on other roadway segments statewide that have similar operating environments. You will also need to determine segment lengths and average annual daily traffic (AADT) volumes for use in developing crash rates.

“Safety Performance Summary” Tab

1. This tab references and summarizes information in the "F+I Crash Analysis Summary" tab for the overall Safety Index (the primary safety performance measure) as well as the secondary Safety performance measures. All data should be entered in the "F + I Crash Analysis Summary" and "5-Year Weighted AADT" tabs, not in the "Safety Performance Summary" tab.
2. Formula links and conditional formatting will need to be adjusted in the "Safety Performance Summary" tab depending on the number of Similar Operating Environments (SOE) in the corridor and which SOE applies to each segment of the corridor.

Crashes on Corridor Segments

1. Start with the Excel spreadsheets provided by ADOT for crashes on the State Highway System in the five-year analysis period (years 2009-2013 in this example). These files are called 2009.xls, 2010.xls, 2011.xls, 2012.xls, and 2013.xls. These files should have multiple columns that start with Incident, Unit, and Person.
2. For each of the Excel spreadsheets, create a new shapefile in ArcGIS of the crash data by plotting the crash locations in ArcGIS using the ‘Add XY Data’ function and the IncidentLatitude and IncidentLongitude columns in the Excel spreadsheets. Then convert the coordinate system to NAD 83 datum so distances are in feet.
3. Query the crash shapefiles on the Incident InjurySeverityDesc field to only display fatal and incapacitating injury crashes and on the UnitNumber to only display records with a unit number of “1”. This results in one crash record for each fatal and incapacitating injury crash on the State Highway System.
4. Query the crash shapefiles on the IncidentOnroad field to only display fatal and incapacitating injury crashes on mainline segments (these typically are the roadway name in the cardinal direction and the roadway name with a zero after a space in the non-cardinal direction: e.g., I 040 and I 040 0) and to exclude crashes on ramps, frontage roads, and at interchanges (these typically have the roadway name with a one or two or series of numbers/letters at the end: e.g., I040 2 and I 040001G). Also, query the crash shapefiles on the IncidentCrossingFeature field to only display those crashes occurring along the study corridor based on the milepost limits of the corridor (e.g., M000 to M196). Visually inspect the selected crashes to confirm they are along the study corridor and make manual adjustments to the dataset if needed.
5. Copy into the “Corridor Crashes F + I” tab the crash records from the five years of crash data that are identified as occurring on the corridor being studied.
6. Determine how many fatal and incapacitating injury crashes occurred in each direction (based on the UnitTravelDirectionDesc field) within each corridor segment for each analysis year and enter this information into the highlighted cells in the corridor-related cells (bottom half) of Columns D and E for fatal crashes and Columns G and H for incapacitating injury crashes in the “F + I Crash Analysis Summary” tab in the Excel file named “SR-95 Safety Index - 09-07-15.xlsx”.

Similar Operating Environments (SOE) in Corridor

1. Using the NAD 83 datum, for the “Highway and Interstate SOEs” tab in the Excel file named “SR-95 Safety Index - 09-07-15.xlsx” create a new shapefile in ArcGIS of the SOE roadway network data by plotting the roadway segment locations in ArcGIS using the ‘Add XY Data’ function and the SwT_X, SwT_Y, NeT_X, and NeT_Y columns in the Excel spreadsheet.
2. Overlay the SOE roadway network data on the corridor segment linework to identify which SOE category applies to each segment of the corridor. If a corridor segment contains portions of multiple SOE categories, designate the corridor segment as the SOE category that covers the majority of the segment length. If there is no majority SOE category in a segment, designate the segment as the SOE category with the lowest statewide average crash frequency and rate

values per the “Statewide F+I Summary_WghtdAADT” tab in the Excel file named “SR-95 Safety Index - 09-07-15.xlsx”. Enter this information in Column B (Similar Operating Environment) of the “F + I Crash Analysis Summary” tab.
3. Copy and paste into the top part of the "F + I Crash Analysis Summary" tab the Statewide tables for those SOE categories found within the corridor from the "Statewide F+I Summary_WghtdAADT" tab. In the SR 95 example, the 2 or 3 Lane Undivided Highway and the 4 or 5 Lane Undivided Highway SOEs have been pasted in
4. This information then feeds into the "Crash % Indices" and "Safety Index" tabs. Formula links in the "Crash % Indices" and "Safety Index" tabs will need to be adjusted to make sure the appropriate Statewide SOE values are referenced for each segment of the corridor.

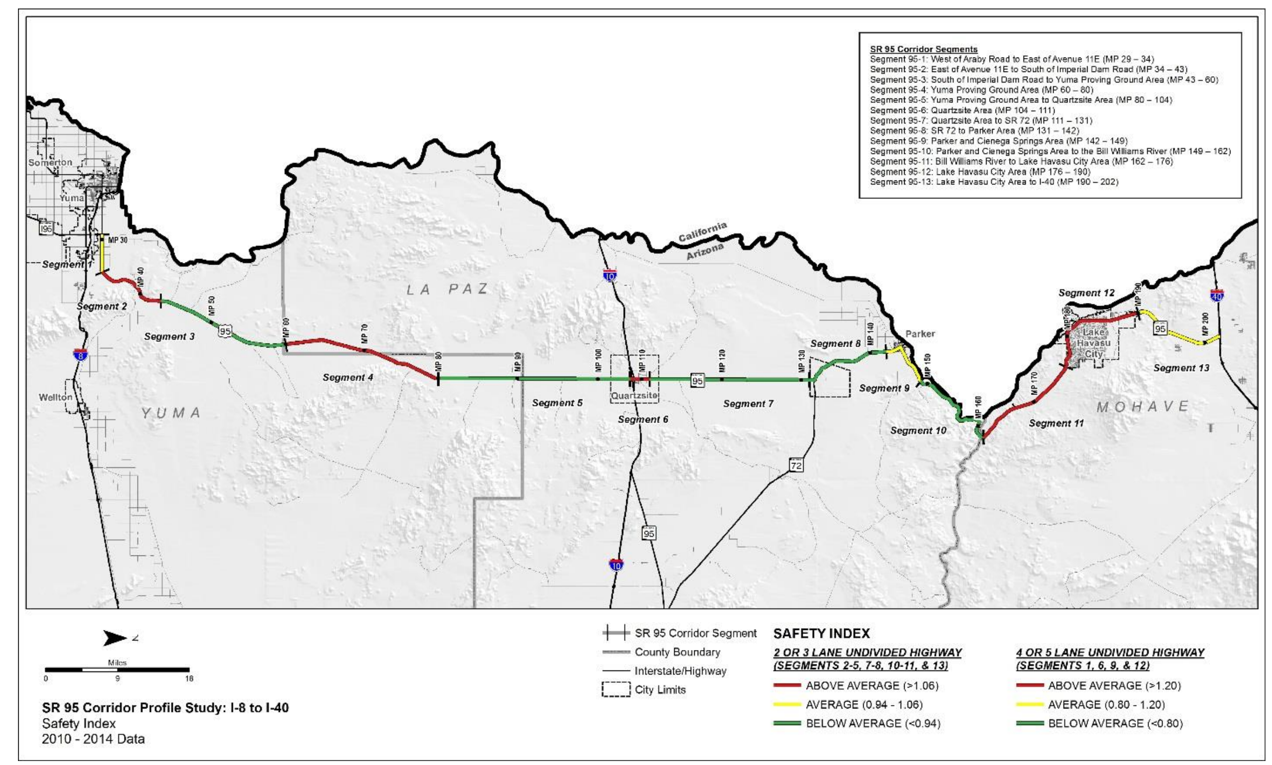
<u>Segment AADTs</u>

1. Obtain the five years of AADT data that correspond to the crash data analysis period. This data is available on ADOT's Data and Analysis AADT webpage (http://azdot.gov/planning/DataandAnalysis).
2. Set up tables similar to the ones created in the “5-Year Weighted AADT” tab in the Excel file named “SR-95 Safety Index - 09-07-15.xlsx” for SR-95 that list the count stations by Loc ID, BMP, EMP, and Length and paste in the bi-directional AADT as well as the directional AADT values. Where AADT values are missing (common for directional AADTs), use the adjacent count station's values or ratio of values as appropriate. Where directional AADTs are missing for several consecutive count stations, assume a 50/50 split of the overall AADT. Yellow highlighted cells indicate where the raw data either was not available or was modified to sum correctly.
3. Create formulas that calculate a weighted average AADT based on length for each corridor segment as shown in the smaller table for each year. The format of the tables and the most current year of data should already have been created in the Mobility Index spreadsheet in the most current year HPMS tab.
4. This information then feeds into the table showing the weighted average AADTs for each segment, which goes into the "F + I Crash Analysis Summary" tab.

<u>Safety Index Calculation</u>

1. Once the fatal and incapacitating injury crashes, segment lengths, and AADTs on corridor segments and similar OE statewide segments have been entered into the highlighted cells in the “F + I Crash Analysis Summary” tab, existing formulas will use that data to calculate crash frequency and rate values and ranges of average values for these parameters in the F + I Crash Analysis Summary tab.
2. In the “Safety Index” tab of the Excel file named “SR-95 Safety Index - 09-07-15.xlsx”, existing formulas will combine the crash frequency and rate values to create a safety index for each corridor segment that compares the performance of a particular segment to the performance of similar SOE statewide segments.
3. Safety index values are categorized (and colorized) as performing Above Average (red color), Average (yellow color), or Below Average (green color) through existing formulas and conditional formatting in the Safety Index tab based on the statewide average being plus or minus one standard deviation from the mean statewide average for each of the five years for SOE statewide segments. Values above average (higher values) equate to worse performance, as this is how safety performance is generally reported (e.g., higher crash frequency or rate typically means worse safety performance).
4. Create a map showing the Safety Index by color for each segment.

Segment	Similar Operating Environment	NB Fatal Crashes 2010-2014	SB Fatal Crashes 2010-2014	NB Incapacitating Injury Crashes 2010 - 2014	SB Incapacitating Injury Crashes 2010-2014	Segment Length (mi)	NB Directional Weighted Average AADT Volume 2010-2014	SB Directional Weighted Average AADT Volume 2010-2014	NB Directional Safety Index (SI)	NB Directional Safety Index Description	SB Directional Safety Index (SI)	SB Directional Safety Index Description	Overall Safety Index	Overall Safety Index Description
95-1	4 or 5 Lane Undivided Highway	1	1	2	2	3	5667	5667	1.13	Average	1.13	Average	1.13	Average
95-2	2 or 3 Lane Undivided Highway	3	0	1	2	5	3631	3683	3.60	Above Average	0.16	Below Average	1.88	Above Average
95-3	2 or 3 Lane Undivided Highway	0	0	2	0	9	1681	1672	0.11	Below Average	0.00	Below Average	0.06	Below Average
95-4	2 or 3 Lane Undivided Highway	2	1	2	0	10	912	888	2.00	Above Average	0.95	Average	1.48	Above Average
95-5	2 or 3 Lane Undivided Highway	0	2	0	0	12	1163	1129	0.00	Below Average	1.39	Above Average	0.69	Below Average
95-6	4 or 5 Lane Undivided Highway	1	0	0	0	1	3296	3296	2.80	Above Average	0.00	Below Average	1.40	Above Average
95-7	2 or 3 Lane Undivided Highway	0	0	0	0	10	1310	1271	0.00	Below Average	0.00	Below Average	0.00	Below Average
95-8	2 or 3 Lane Undivided Highway	0	0	4	0	6	2840	2780	0.28	Below Average	0.00	Below Average	0.14	Below Average
95-9	4 or 5 Lane Undivided Highway	2	0	3	1	3	5794	5794	1.81	Above Average	0.06	Below Average	0.93	Below Average
95-10	2 or 3 Lane Undivided Highway	0	1	5	2	7	2979	2350	0.27	Below Average	0.98	Average	0.63	Below Average
95-11	2 or 3 Lane Undivided Highway	2	2	5	5	7	3316	2166	1.81	Above Average	2.08	Above Average	1.95	Above Average
95-12	4 or 5 Lane Undivided Highway	2	3	47	45	7	9103	9103	1.47	Above Average	1.71	Above Average	1.59	Above Average
95-13	2 or 3 Lane Undivided Highway	2	0	3	4	6	4145	3991	1.88	Above Average	0.24	Below Average	1.06	Average



Directional Safety Index

See the directions for the Safety Index, with the only difference being that crashes are separated out by direction using the UnitTravelDirectionDesc field in the crash data.

SHSP Emphasis Areas

ADOT’s recently updated Strategic Highway Safety Plan (SHSP) identifies several emphasis areas. The top five SHSP emphasis areas relate to the following driver behaviors:

- Speeding/Aggressive Driving

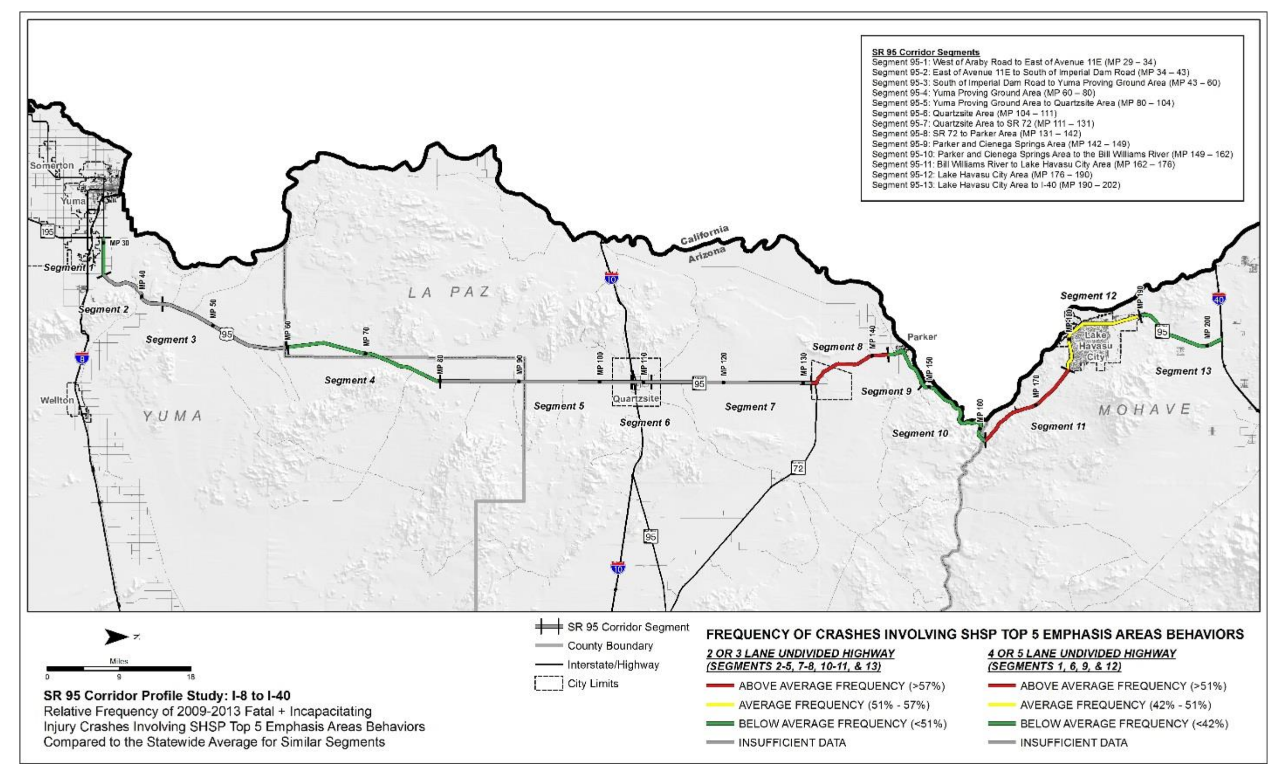
- Impaired Driving
- Lack of Restraint Usage
- Lack of Motorcycle Helmet Usage
- Distracted Driving

To determine how well a particular corridor segment performs in these five emphasis areas, the relative frequencies of the aforementioned driver behaviors at the corridor segment level can be compared to SOE segments statewide. To avoid large swings in performance due to one or two crashes where the sample size is small, the five emphasis areas behaviors are combined to identify crashes that exhibit one or more of the emphasis areas behaviors.

1. Using the fatal and incapacitating injury crash selection set developed for corridor segments, run a query that identifies fatal and incapacitating injury crashes that contain one or more of the field attributes listed below:
    a. Speeding/Aggressive Driving – PersonViol codes of Exceeded Lawful Speed, Followed Too Closely, Unsafe Lane Change, Passed in No-Passing Zone, Other Unsafe Passing;
    b. Impaired driving – PersonPh_2 code of Physical Impairment, PersonPh_3 code of Fell Asleep/Fatigued, PersonPh_4 code of Alcohol, PersonPh_5 code of Drugs, PersonPh_6 code of Medication;
    c. Lack of Restraint Usage – PersonSafe code of None Used;
    d. Lack of Motorcycle Helmet Usage – PersonSafe code of None Used (already included in Lack of Restraint Usage);
    e. Distracted driving – PersonViol codes of Inattention/Distraction and Electronic Communication Device.
2. Enter the sum of the fatal and incapacitating injury crashes that exhibit one or more of the aforementioned emphasis areas behaviors for the individual corridor segments into the highlighted cells in the bottom half of Column R (SHSP Top 5 Emphasis Area Behaviors) in the "F + I Crash Analysis Summary" tab. Existing formulas use that data to calculate the percentage of total fatal and incapacitating injury crashes involving the emphasis areas behaviors and ranges of average values for these parameters in the "F + I Crash Analysis Summary" tab.
3. In the Crash % Indices tab of the Excel file named "SR-95 Safety Index - 09-07-15.xlsx", existing formulas and conditional formatting compare the performance of a particular segment to the performance of SOE statewide segments for the emphasis areas behaviors and categorize (and colorize) segments as performing Above Average (red color), Average (yellow color), or Below Average (green color) based on the statewide average being plus or minus one standard deviation from the mean statewide average for each of the five years for SOE statewide segments.
4. Due to the instability of small sample sizes, segment secondary performance measure levels should be removed and replaced with "Insufficient Data" if any of the following criteria are met:
    a) adding or removing one fatal or incapacitating injury crash of the secondary performance measure type (e.g., SHSP Top 5) changes the segment performance value two levels (regardless of the number of fatal + incapacitating injury crashes in the segment over the five-year analysis period);
    b) there are fewer than five total fatal + incapacitating injury crashes (of any type) in a segment.
5. If the average segment crash frequency of the overall corridor is fewer than two fatal + incapacitating injury crashes of that secondary performance measure type over the five-year analysis period, the entire secondary performance measure should be eliminated from further analysis due to insufficient sample size. In the SR-95 example, some of the segments in the SHSP Top 5 Emphasis Areas Behaviors are eliminated due to insufficient sample size.
6. Update the conditional formatting of Column E and the performance level value in Column F of the "Crash % Indices" tab to account for the "Insufficient Data" segments.
7. Create a map showing the comparative frequency of fatal and incapacitating injury crashes that exhibit one or more of the aforementioned SHSP emphasis areas behaviors by color for each segment.

Segment Similar Operating Environment Type	Total Statewide Fatal + Incapacitating Injury Crashes	Total Statewide Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	% of Total Statewide Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors			
			Annual Average (Mean)	Standard Deviation (SD)	Lower Limit of Average (Mean - SD)	Upper Limit of Average (Mean + SD)
2 or 3 Lane Undivided Highway	1322	718	54%	3%	51%	57%
4 or 5 Lane Undivided Highway	476	224	47%	4%	42%	51%

Corridor Segment	Segment Similar Operating Environment Type	Segment Fatal + Incapacitating Injury Crashes	Segment Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	% of Segment Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	Frequency of Segment Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors
95-1	4 or 5 Lane Undivided Highway	6	1	17%	Below Average
95-2	2 or 3 Lane Undivided Highway	6	2	33%	Insufficient Data
95-3	2 or 3 Lane Undivided Highway	2	1	50%	Insufficient Data
95-4	2 or 3 Lane Undivided Highway	5	1	20%	Below Average
95-5	2 or 3 Lane Undivided Highway	2	1	50%	Insufficient Data
95-6	4 or 5 Lane Undivided Highway	1	1	100%	Insufficient Data
95-7	2 or 3 Lane Undivided Highway	0	0	0%	Insufficient Data
95-8	2 or 3 Lane Undivided Highway	4	3	75%	Above Average
95-9	4 or 5 Lane Undivided Highway	6	1	17%	Below Average
95-10	2 or 3 Lane Undivided Highway	8	4	50%	Below Average
95-11	2 or 3 Lane Undivided Highway	14	9	64%	Above Average
95-12	4 or 5 Lane Undivided Highway	97	44	45%	Average
95-13	2 or 3 Lane Undivided Highway	9	4	44%	Below Average



Crash Unit Types

ADOT's SHSP also identifies emphasis areas that relate to the following unit or entity type involved in crashes:

- Heavy Vehicles (Trucks)
- Motorcycles
- Non-Motorized Travelers (pedestrians and bicyclists)

To determine how well a particular corridor segment performs in these emphasis areas, the relative frequencies of the aforementioned crash unit types at the corridor segment level can be compared to SOE segments statewide. To avoid large swings in performance due to one or two crashes where the sample size is small, these emphasis areas should only be mapped if the sample size is sufficiently large.

1. Follow the same steps as the SHSP Emphasis Areas methodology except run a query that identifies fatal and incapacitating injury crashes that contain one or more of the field attributes listed below:
    a. Truck-involved crashes – all UnitBodyStyleDesc codes that start with Truck;
    b. Motorcycle-involved crashes – all UnitBodyStyleDesc codes that start with Motorcycle;
    c. Non-motorized traveler-involved crashes – PersonTypeDesc codes of Pedestrian or Pedalcyclist.
2. Enter the sum of the fatal and incapacitating injury crashes that exhibit one or more of the aforementioned crash unit types for the individual corridor segments into the highlighted cells in the corridor-specific bottom half of the "F + I Crash Analysis Summary" tab in Column T (Trucks), Column V (Motorcycles), and Column X (Non-Motorized Travelers). Existing formulas use that data to calculate the percentage of total fatal and incapacitating injury crashes involving the emphasis areas behaviors and ranges of average values for these parameters in the "F + I Crash Analysis Summary" tab.
3. In the Crash % Indices tab of the Excel file named "SR-95 Safety Index - 09-07-15.xlsx", existing formulas and conditional formatting compare the performance of a particular segment to the performance of SOE statewide segments for each respective Crash Unit Type and categorize (and colorize) segments as performing Above Average (red color), Average (yellow color), or Below Average (green color) based on the statewide average being plus or minus one standard deviation from the mean statewide average for each of the five years for SOE statewide segments.
4. Due to the instability of small sample sizes, segment secondary performance measure levels should be removed and replaced with "Insufficient Data" if any of the following criteria are met:
    a) adding or removing one fatal or incapacitating injury crash of the secondary performance measure type (e.g., Trucks) changes the segment performance value two levels (regardless of the number of fatal + incapacitating injury crashes in the segment over the five-year analysis period);
    b) there are fewer than five total fatal + incapacitating injury crashes (of any type) in a segment.
5. If the average segment crash frequency of the overall corridor is fewer than two fatal + incapacitating injury crashes of that secondary performance measure type over the five-year analysis period, the entire secondary performance measure should be eliminated from further analysis due to insufficient sample size. In the SR-95 example, the Truck, Motorcycle, and Non-Motorized secondary performance measures are eliminated due to insufficient sample size.
6. Update the conditional formatting of Column E and the performance level value in Column F of the "Crash % Indices" tab to account for the "Insufficient Data" segments.
7. For performance measures that have one or more segments that do not have "Insufficient Data", create a map showing the comparative frequency of fatal and incapacitating injury crashes that involve the specified crash unit types by color for each segment. In the SR-95 example, the Truck, Motorcycle, and Non-Motorized secondary performance measures are eliminated due to insufficient sample size so there are no maps for these measures.

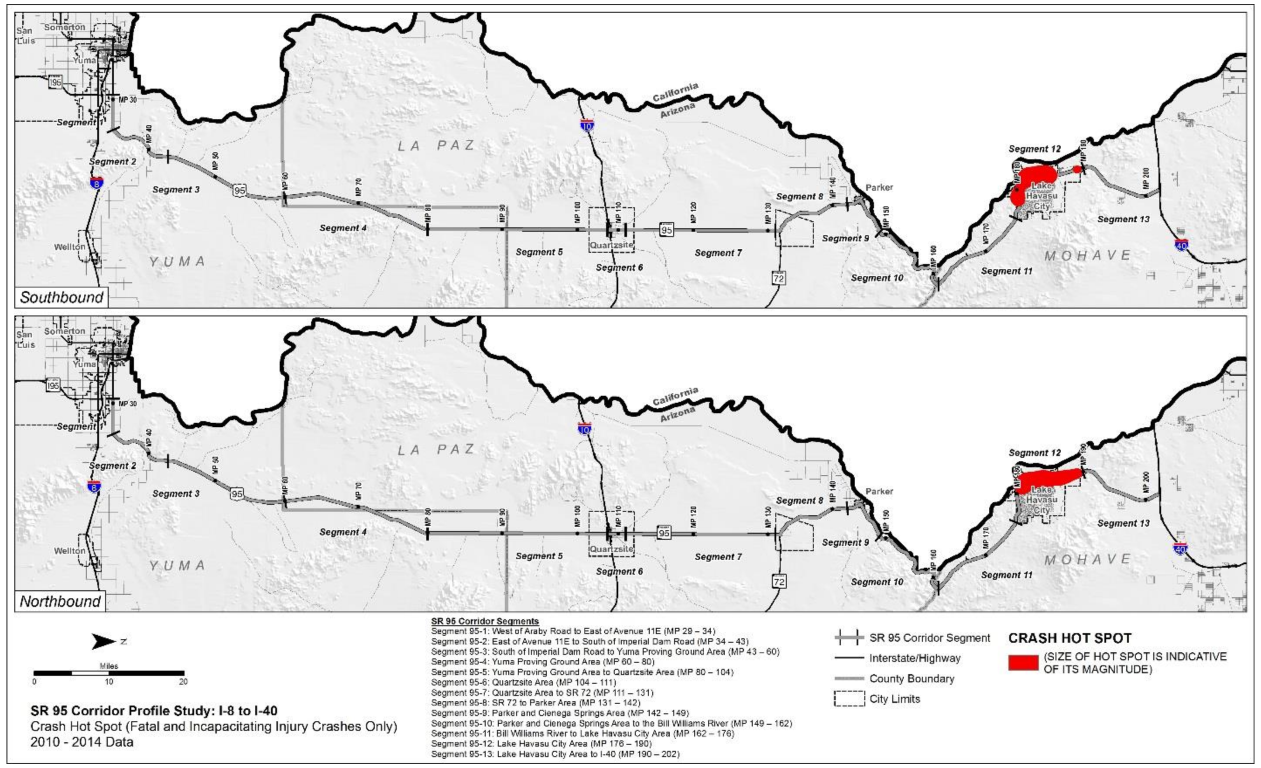
Segment Similar Operating Environment Type	Total Statewide Fatal + Incapacitating Injury Crashes	Total Statewide Fatal + Incapacitating Injury Crashes Involving Trucks	% of Total Statewide Fatal + Incapacitating Injury Crashes Involving Trucks			
			Annual Average (Mean)	Standard Deviation (SD)	Lower Limit of Average (Mean - SD)	Upper Limit of Average (Mean + SD)
2 or 3 Lane Undivided Highway	1322	81	6%	1%	5%	7%
4 or 5 Lane Undivided Highway	476	37	8%	2%	6%	10%

Corridor Segment	Segment Similar Operating Environment Type	Segment Fatal + Incapacitating Injury Crashes	Segment Fatal + Incapacitating Injury Crashes Involving Trucks	% of Segment Fatal + Incapacitating Injury Crashes Involving Trucks	Frequency of Segment Fatal + Incapacitating Injury Crashes Involving Trucks
95-1	4 or 5 Lane Undivided Highway	6	1	17%	Insufficient Data
95-2	2 or 3 Lane Undivided Highway	6	3	50%	Insufficient Data
95-3	2 or 3 Lane Undivided Highway	2	0	0%	Insufficient Data
95-4	2 or 3 Lane Undivided Highway	5	1	20%	Insufficient Data
95-5	2 or 3 Lane Undivided Highway	2	0	0%	Insufficient Data
95-6	4 or 5 Lane Undivided Highway	1	1	100%	Insufficient Data
95-7	2 or 3 Lane Undivided Highway	0	0	0%	Insufficient Data
95-8	2 or 3 Lane Undivided Highway	4	1	25%	Insufficient Data
95-9	4 or 5 Lane Undivided Highway	6	2	33%	Insufficient Data
95-10	2 or 3 Lane Undivided Highway	8	0	0%	Insufficient Data
95-11	2 or 3 Lane Undivided Highway	14	0	0%	Insufficient Data
95-12	4 or 5 Lane Undivided Highway	97	5	5%	Insufficient Data
95-13	2 or 3 Lane Undivided Highway	9	1	11%	Insufficient Data

Safety Hot Spots

A "hot spot" analysis identifies abnormally high concentrations of crashes. This analysis of fatal and incapacitating injury crashes along the study corridor by direction of travel involves the following steps:

1. Using the fatal and incapacitating injury crashes selection set developed previously for the Safety Index for corridor segments, separate the crashes by direction of travel using the field named UnitTravelDirectionDesc.
2. In ArcGIS Toolbox, open the 'Kernel Density' tool. The input file is the fatal and incapacitating injury crashes selection set by direction file. The population field should be set to 'NONE'. For the output cell size, use a value of 50 feet. For the search radius, use a value of 10,560 feet (2 miles).
3. Create a map showing the results as a raster dataset.
4. Change the Equal Interval map symbology display to have 2 classes, and then manually change the upper limit of the first class to 0.000000035. Then change the first class color to null and the second class color to red (RGB 245 0 0).


Southbound
Northbound
LA PAZ
YUMA
MOHAVE
California
Arizona
Parker
Quartzsite
Wellton
Lake Havasu City
Segment 2
Segment 3
Segment 4
Segment 5
Segment 6
Segment 7
Segment 8
Segment 9
Segment 10
Segment 11
Segment 12
Segment 13
Miles
0
10
20
SR 95 Corridor Profile Study: I-8 to I-40
Crash Hot Spot (Fatal and Incapacitating Injury Crashes Only)
2010 - 2014 Data
SR 95 Corridor Segments
Segment 95-1: West of Araby Road to East of Avenue 11E (MP 29 – 34)
Segment 95-2: East of Avenue 11E to South of Imperial Dam Road (MP 34 – 43)
Segment 95-3: South of Imperial Dam Road to Yuma Proving Ground Area (MP 43 – 60)
Segment 95-4: Yuma Proving Ground Area (MP 60 – 80)
Segment 95-5: Yuma Proving Ground Area to Quartzsite Area (MP 80 – 104)
Segment 95-6: Quartzsite Area (MP 104 – 111)
Segment 95-7: Quartzsite Area to SR 72 (MP 111 – 131)
Segment 95-8: SR 72 to Parker Area (MP 131 – 142)
Segment 95-9: Parker and Cienega Springs Area (MP 142 – 149)
Segment 95-10: Parker and Cienega Springs Area to the Bill Williams River (MP 149 – 162)
Segment 95-11: Bill Williams River to Lake Havasu City Area (MP 162 – 176)
Segment 95-12: Lake Havasu City Area (MP 176 – 190)
Segment 95-13: Lake Havasu City Area to I-40 (MP 190 – 202)
SR 95 Corridor Segment
Interstate/Highway
County Boundary
City Limits
CRASH HOT SPOT
(SIZE OF HOT SPOT IS INDICATIVE OF ITS MAGNITUDE)

Freight Performance Area Calculation Methodologies

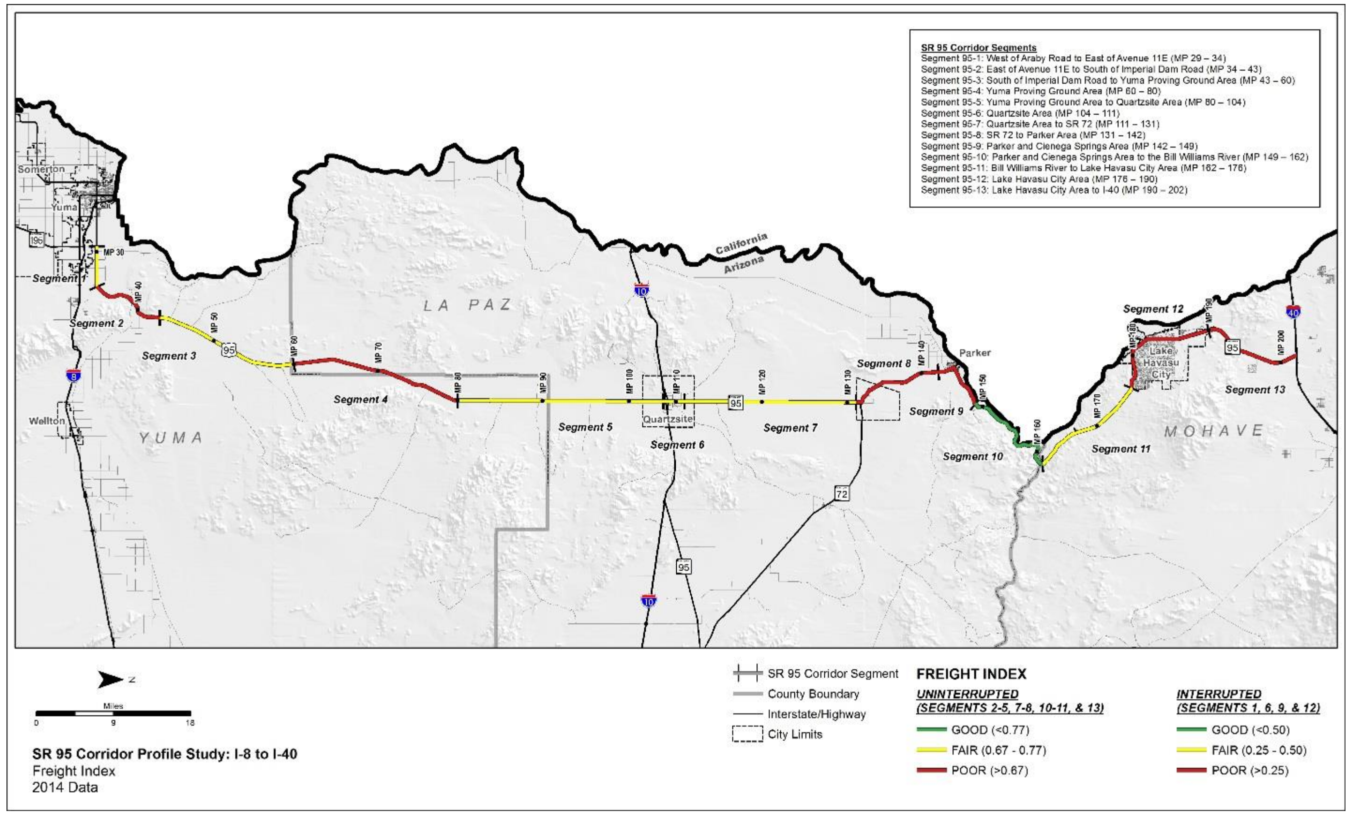
The Appendix summarizes the approach for developing the primary and secondary performance measures in the Freight Performance Area as shown in the following graphic.

Freight Index

3. Open the file called Freight_Index_Example.xlsx. This file contains several tabs. The “Freight Performance Area” tab is a summary of the various performance measure results for the Freight Performance Area.
4. In the “Arizona_FHWA_Monthly_Static_Fil” tab, identify the TMCs (data collection sites) that correspond to the desired corridor. TMCs with a “P” denote positive direction of travel (north or east) and TMCs with a “N” denote negative direction of travel (south or west). Note: Some TMCs will not have a corresponding TMC in the opposite direction of travel. It is important not to treat a missing value as a zero in the following calculations.
5. Using the latitude/longitude values for the TMCs in the “Arizona_FHWA_Monthly_Static_Fil” tab and GIS, determine which TMCs apply to which corridor segment. Note: TMCs have a segment length that likely does not coincide with a corridor segment boundary so it is necessary to assign each TMC segment to the corridor segment that contains the majority of the TMC segment length.
6. In the “Congestion Metrics.xlsx Sheet1” tab, isolate the data to only show the desired TMCs.
7. Create a new “Speed Limit” column that assigns the speed limit of each TMC based on the speed limit information provided in the “SpeedLimit” tab. This is shown as column Z in the “Sheet1 with calculations” sample tab.
8. Create a new “Assumed truck free-flow speed” column that is the lower value of the speed limit column or 65 miles per hour (mph). This “cap” of 65 mph accounts for governors that trucks often have that restrict truck speeds to no more than 65 mph. This is shown as column AB in the “Sheet1 with calculations” sample tab.
9. Create a new “Trucks_PTI” column that divides the “Assumed truck free-flow speed” column (column AB in the “Sheet1 with calculations” tab) by the “trucks_P05” 5th percentile speed column (column X in Sheet1). This creates the truck planning time index (TPTI) and is shown as column AG in the “Sheet1 with calculations” sample tab.
10. Create a new “Trucks_Peak PTI” column that lists the maximum TPTI value that corresponds to each TMC using the MAX function in Excel. There are typically four different TPTIs for each TMC: AM Peak, Mid Day Peak, PM Peak, and Off Peak. Note: one or more TPTI value may be missing so it is important that the MAX function has the correct cell range for each TMC. This is shown as column AK in the “Sheet1 with calculations” sample tab.
11. Create a new “Segment Average Trucks_Peak PTI” column that lists the average TPTI value that corresponds to each corridor segment using the AVERAGE function in Excel. This is shown as column AQ in the “Sheet1 with calculations” sample tab.
12. Create a new “Combined Average Peak TPTI” column that averages the TPTI in each direction of travel. This is shown as column BP in the “Sheet1 with calculations” sample tab.
13. Create a new Freight Index column that inverts the “Combined Average Peak TPTI” values by segment. This is shown as column BS in the “Sheet1 with calculations” sample tab.
14. Categorize the Freight Index values by segment using the appropriate scale for Interrupted or Uninterrupted flow facilities. Colorize the Freight Index values by segment using the color red for Poor, yellow for Fair, and green for Good. This is shown as column C in the “Freight Performance Area” sample tab.

Segment	Facility Type	Freight Index (FI) (1/TPTI)	Freight Index Description
1	Interrupted	0.31	Fair
2	Uninterrupted	0.64	Poor
3	Uninterrupted	0.76	Fair
4	Uninterrupted	0.13	Poor
5	Uninterrupted	0.74	Fair
6	Interrupted	0.35	Fair
7	Uninterrupted	0.70	Fair
8	Uninterrupted	0.53	Poor
9	Interrupted	0.24	Poor
10	Uninterrupted	0.78	Good
11	Uninterrupted	0.73	Fair
12	Interrupted	0.22	Poor
13	Uninterrupted	0.37	Poor

Create a map showing the Freight Index categories by color for each segment.



Directional TPTI

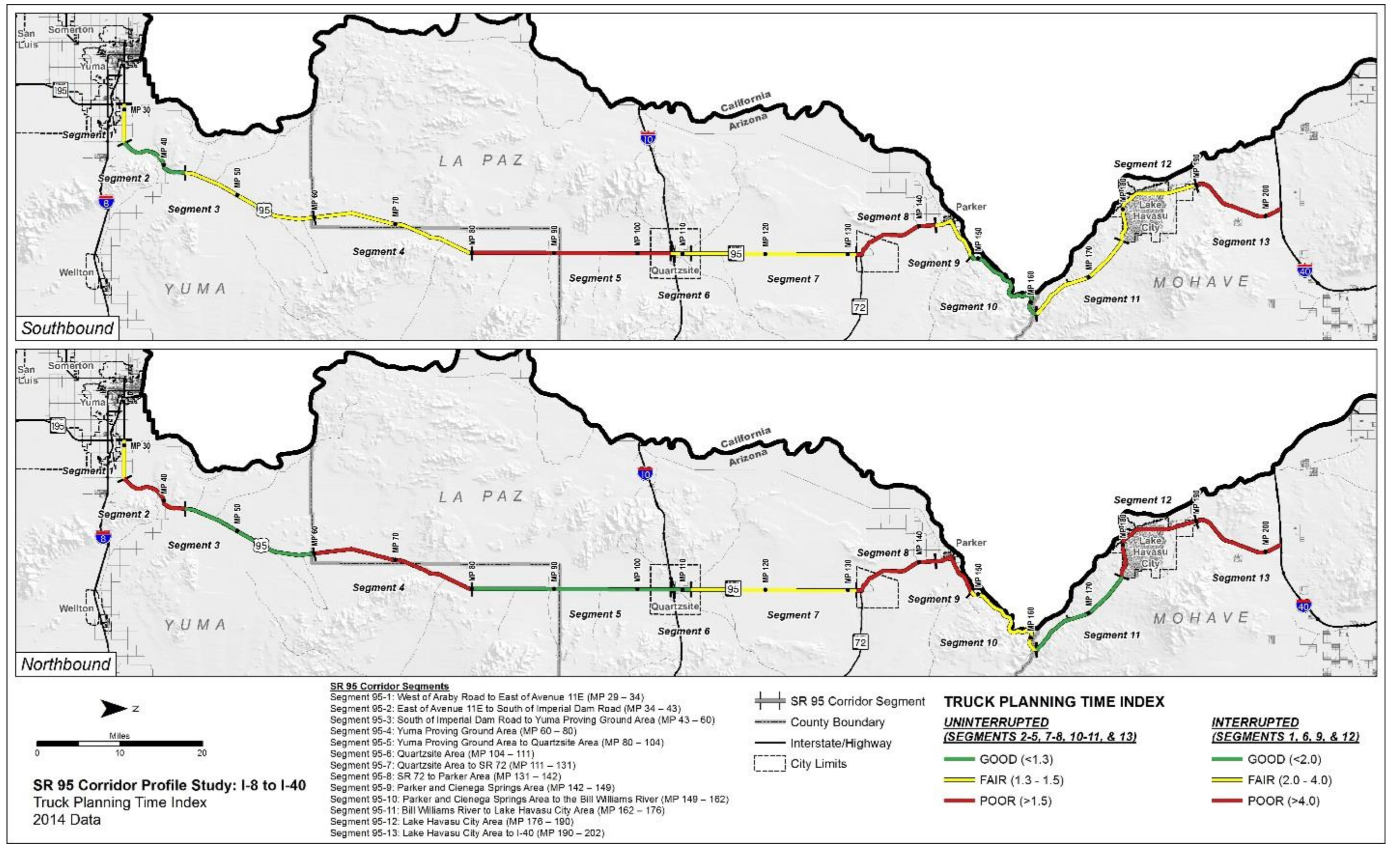
1. Follow steps 1-9 of the Freight Index methodology to calculate the Directional TPTI.
2. Categorize the Directional TPTI values according to the appropriate thresholds, depending if the segment is Interrupted or Uninterrupted flow. Colorize the Directional TPTI values by segment using the color red for Poor, yellow for Fair, and green for Good. This is shown as columns L and M in the “Freight Performance Area” sample tab.

Segment	Northbound Average TPTI	Southbound Average TPTI	Combined Average Peak TPTI
1	3.46	2.95	3.21
2	1.96	1.17	1.56
3	1.30	1.34	1.32
4	13.64	1.46	7.55
5	1.11	1.57	1.34
6	1.97	3.76	2.86
7	1.40	1.44	1.42
8	2.24	1.50	1.87
9	4.89	3.38	4.13
10	1.33	1.24	1.29
11	1.29	1.44	1.37
12	5.39	3.80	4.60
13	2.36	3.06	2.71

TPTI Thresholds

	Uninterrupted	*Interrupted*
Good	< 1.3	< 2.0
Fair	1.3-1.5	2.0-4.0
Poor	>1.5	> 4.0

Create a directional map showing the Directional TPTI by color for each segment.



Directional TTTI

Follow steps 1-6 of the Freight Index methodology.

Create a new “Trucks_TTI” column that divides the “Assumed truck free-flow speed” column (column AB in the “Sheet1 with calculations” tab) by the “trucks_mean” average speed column (column N in Sheet1). This creates the truck travel time index (TTTI) and is shown as column AE in the “Sheet1 with calculations” sample tab.

Create a new “Trucks_Peak TTI” column that lists the maximum TTTI value that corresponds to each TMC using the MAX function in Excel. There are typically four different TPTIs for each TMC: AM Peak, Mid Day Peak, PM Peak, and Off Peak. Note: one or more TPTI value may be missing so it is important that the MAX function has the correct cell range for each TMC. This is shown as column AI in the “Sheet1 with calculations” sample tab.

Create a new “Segment Average Trucks_Peak TTI” column that lists the average TTTI value that corresponds to each corridor segment using the AVERAGE function in Excel. This is shown as column AO in the “Sheet1 with calculations” sample tab.

Create new directional TTTI columns, “Westbound Average TTTI” and “Eastbound Average TTTI”. This is shown as columns BI and BJ in the “Sheet1 with calculations” sample tab.

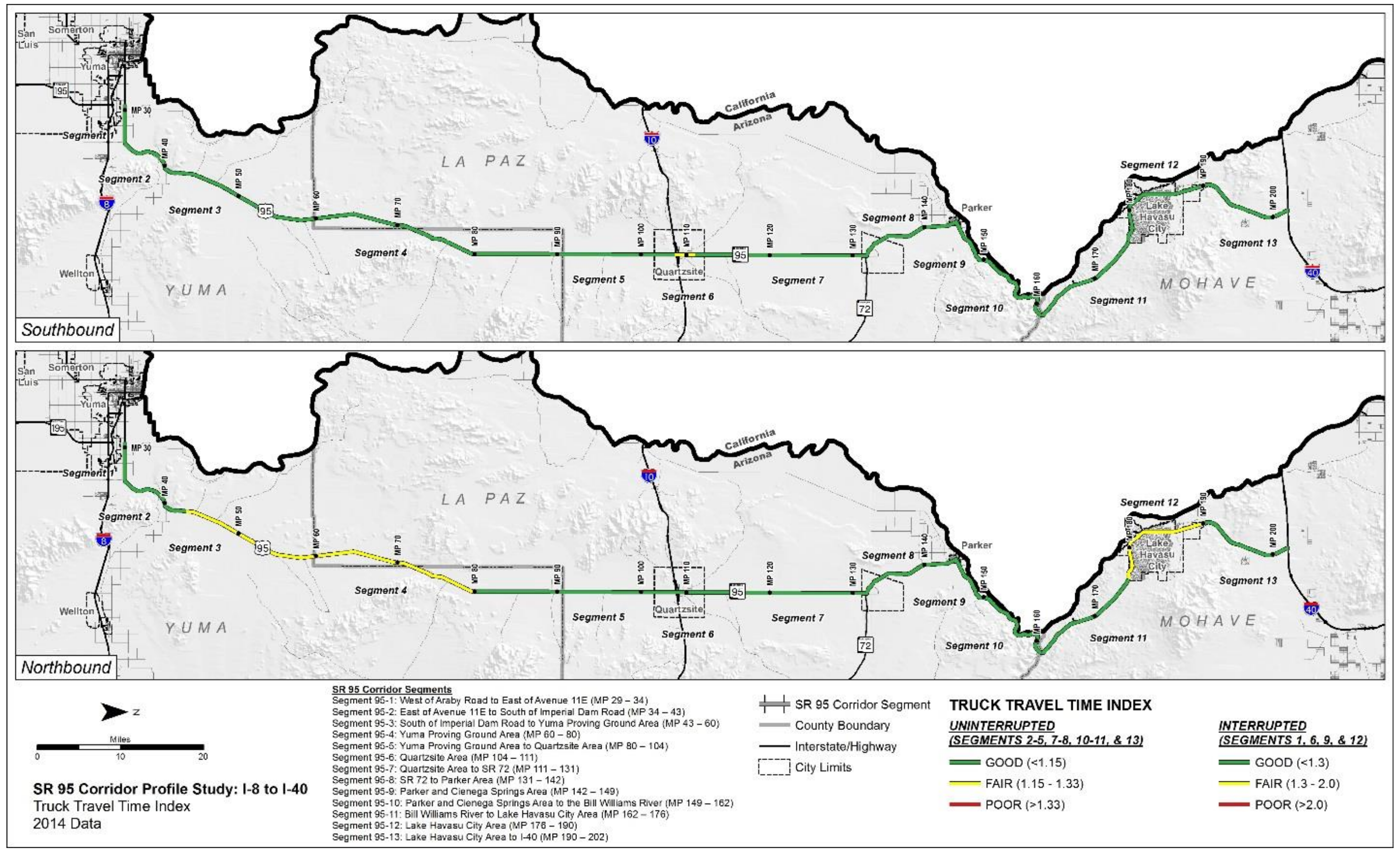
Categorize the Directional TTTI values according to the appropriate thresholds, depending if the segment is Interrupted or Uninterrupted flow. Colorize the values by segment using the color red for Poor, yellow for Fair, and green for Good. This is shown as columns G and H in the “Freight Performance Area” sample tab.

Segment	Northbound Average TTTI	Southbound Average TTTI	Combined Average Peak TTTI
1	1.07	1.06	1.07
2	1.04	1.00	1.02
3	1.30	1.03	1.17
4	1.27	1.06	1.16
5	1.01	1.06	1.04
6	1.06	1.46	1.26
7	1.05	1.04	1.05
8	1.07	1.06	1.06
9	1.09	1.05	1.07
10	1.01	1.04	1.02
11	1.00	1.03	1.01
12	1.34	1.22	1.28
13	1.09	1.07	1.08

TTTI Thresholds

	Uninterrupted	*Interrupted*
Good	< 1.15	< 1.30
Fair	1.15-1.33	1.30-2.00
Poor	> 1.33	> 2.00

1. Create a directional map showing the Directional TTTI by color for each segment.



HCRS Road Closures

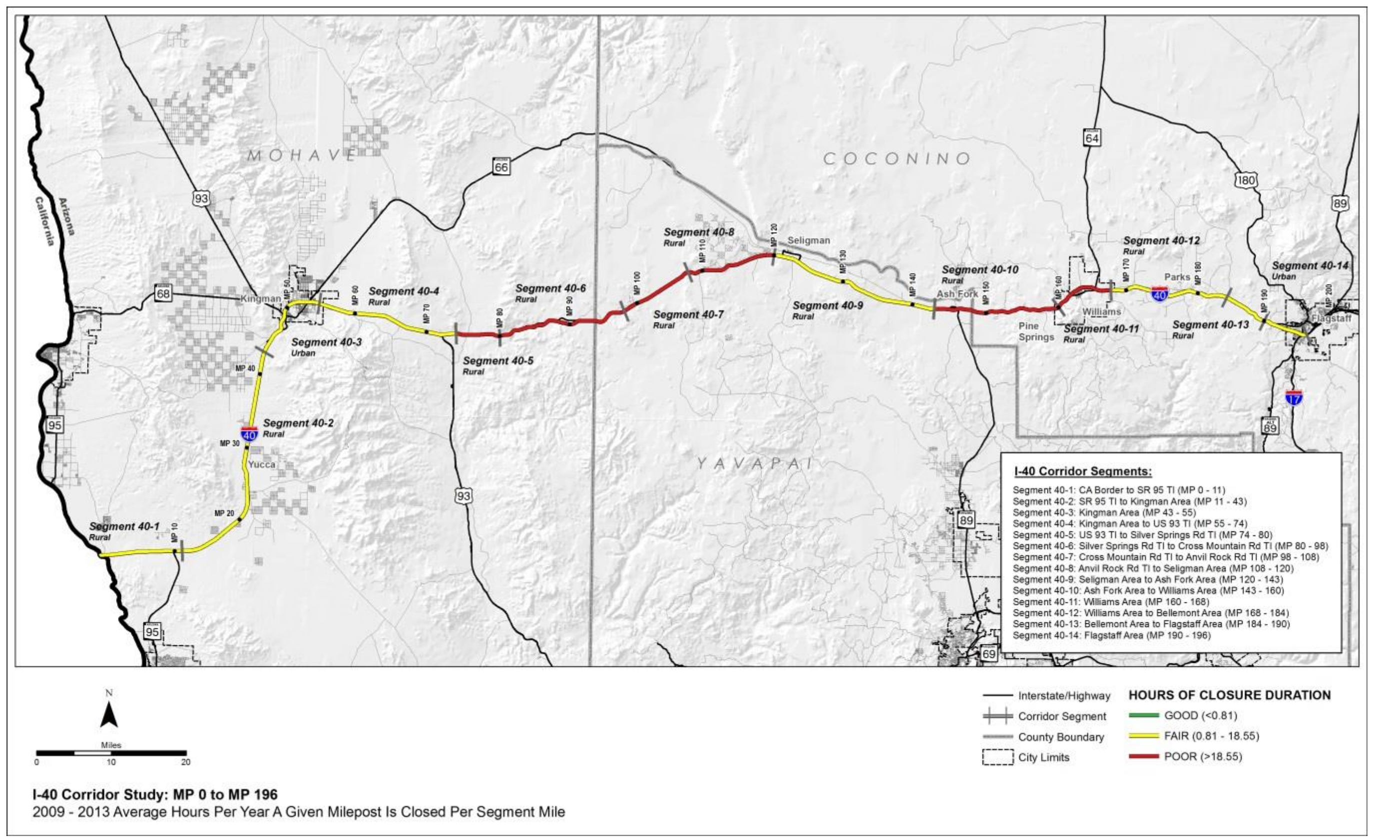
1. Filter the “HCRS Statewide Full Closures” tab to display the closure data corresponding to the desired corridor for the years 2010-2014.
2. Confirm by looking at the hwy_at_mp (column R) and the hwy_to_mp (column S) that the closure milepost limits include at least part of one or more of the corridor segments. For any closures that go beyond the corridor limits, revise the milepost limits to match the corridor limits.
3. Sort the data by milepost using hwy_at_mp (column R).
4. Insert a new column for each milepost in the corridor and label it accordingly. This is shown as columns Z through HM in the “Example Closure Analysis” sample tab.
5. Mark a “1” in each milepost column wherever that milepost was included within the limits of each closure (each row). Closures occurring between mileposts should be assigned to the higher milepost. Closures occurring exactly at a milepost should be assigned to the adjacent milepost. For example, a closure at milepost 2.3 would be marked in the milepost 3 column, as would a closure at milepost 2.0.
6. Insert a new column that sums the “1” values in each row and as a check compare this to the “closure length” column in the “HCRS Statewide Full Closures” tab. The two columns should match. If they don’t, confirm that the “1” values have been input correctly.
7. Insert a new column for each milepost in the corridor and label it accordingly. Create a new formula that takes the clearance time in minutes from the “clearance_mins” column and converts it to hours and places that value in each cell that contains a “1” from step 5. This is shown as columns PK through WX in the “Example Closure Analysis” sample tab.
8. Insert a new column that sums the hours of clearance times in each row and as a check compare this to the “hours of closure duration accounting for length” column in the “HCRS Statewide Full Closures” tab. The two columns should match. If they don’t, confirm that the formulas have been input correctly.
9. Identify the total closure duration in each corridor segment by summing the hours of clearance times values in each milepost for each segment. This should be done bi-directionally (both directions of travel combined) although it can also be done for each direction separately, if desired, based on the “hwy_dir_descr” column in the “HCRS Statewide Full Closures” tab. Note that some closures may apply to both directions so they need to be counted in each of the separate directions if values for each direction are calculated separately. This is shown in cells PQ258 through QF264 in the “Example Closure Analysis” sample tab.
10. Divide the total closure duration per segment by the length of each segment and by the number of years of data to get the average hours per year a given milepost is closed per segment mile in each segment. This is shown in cells B51 through O56 in the “Example Closure Summary” sample tab.
11. Input the statewide mean and standard deviation of the average hours per year a given milepost is closed per segment mile. These statewide values are shown in column R in the “Example Closure Summary” sample tab. Add one standard deviation to the statewide mean to get an upper limit for an average scaling category. Subtract one standard deviation from the statewide mean to get a lower limit.
12. Categorize the average hours per year a given milepost is closed per segment mile in each segment with Poor > upper average limit, Fair between upper and lower average limits, and Good < lower average limit. Colorize the values by segment using the color red for Poor, yellow for Fair, and green for Good. This is shown as column Q in the “Freight Performance Area” sample tab.

Segment	Average Hours Per Year Given Milepost Is Closed Per Segment Mile
1	2.28
2	0.61
3	0.16
4	0.23
5	0.11
6	1.21
7	0.44
8	0.50
9	0.90
10	0.85
11	1.27
12	1.31
13	0.86

Average Hours Per Year a Given Milepost Is Closed Per Segment Mile

Good	< 2.21
Fair	2.21-18.04
Poor	>18.04

13. Create a map showing the average hours per year a given milepost is closed per segment mile by color for each segment.



Truck Restrictions

1. Geolocate the existing truck height restrictions in the corridor using the data provided by the ADOT Intermodal Transportation Department Engineering Permits Section.
2. If truck restrictions exist along the corridor, create a map showing the truck height restrictions, with different symbols for locations where ramps exist that allow the restriction to be avoided and for locations where ramps do not exist and the restriction cannot be avoided.